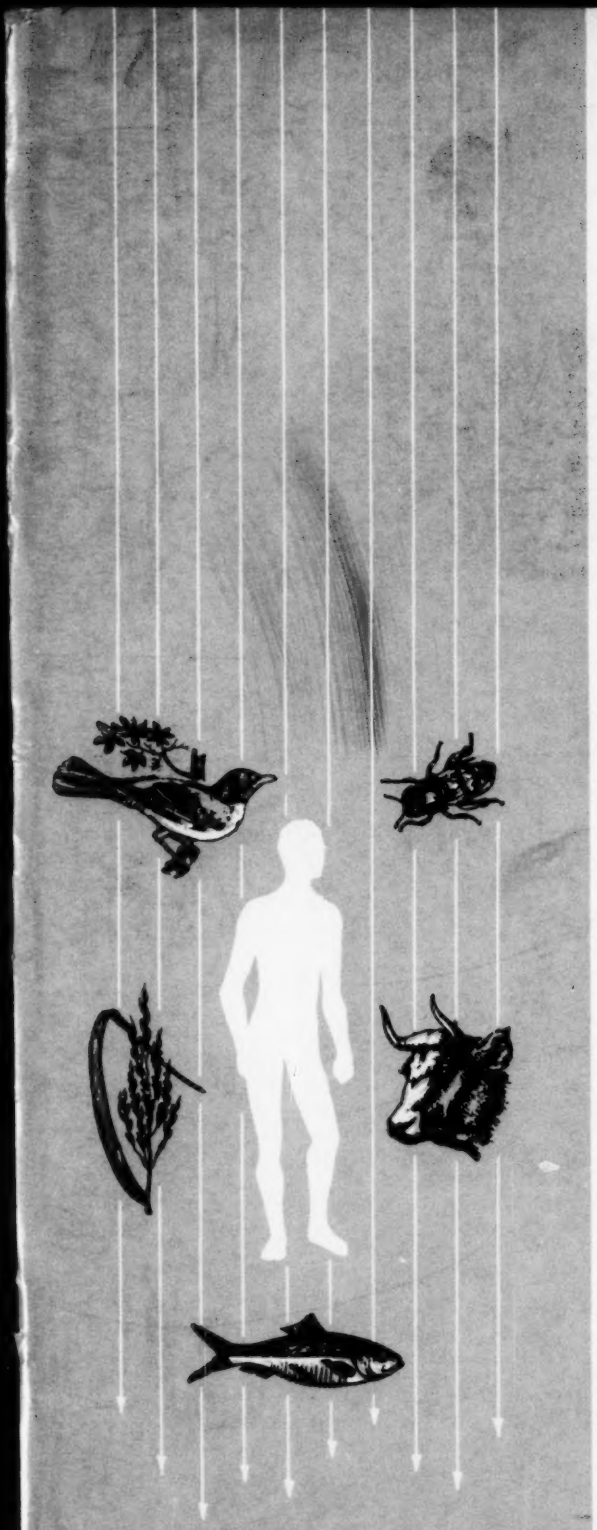

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PESTICIDES IN SOIL

Pesticide Residue Levels in Soils and Crops, FY-70—National Soils Monitoring Program (II)

A. B. Crockett,[1] G. B. Wiersma,[1] H. Tai,[2] W. G. Mitchell,[2]
P. F. Sand,[3] and Ann E. Carey[4]

ABSTRACT

This data report is a summary of Fiscal Year 1970 results of the National Soils Monitoring Program. It includes data on pesticide applications, soil residues, and crop residues collected from 1,506 cropland sites in 35 States. Pesticide application data are summarized by all sites and by State. Soil residue data are itemized similarly, but also include data by cropping region. Tables generally give the number of sites, number of times a pesticide was applied or detected, percent occurrence, arithmetic mean application rate or residue level, and range of residues detected. For some data, geometric means or 50 percentile levels, both with 95 percent confidence intervals, are presented.

Pesticides applied most frequently were atrazine, 2,4-D, captan, and malathion. Farmers in cotton and corn cropping regions applied the most pesticides; those in grass hay and mixed hay areas applied the least. Dieldrin, DDTR, aldrin, chlordane, and heptachlor epoxide were the chlorinated hydrocarbon residues found in soil most frequently. Highest residue levels were found in the corn and cotton cropping regions; lowest levels were in the hay, general farming, and small-grain soils.

Introduction

The National Soils Monitoring Program is an integral part of the National Pesticide Monitoring Program (NPMP). The Program was initiated at the recommendation of the President's Science Advisory Committee report of 1964 entitled "Use of Pesticides." This committee recommended that appropriate Federal agencies "develop a continuing network to monitor residue levels in air, water, soil, man, wildlife, and fish" (*1*).

The objective of NPMP is to determine levels and trends of pesticides and their degradation products in the various components of the environment (*2*). The initial goal, establishment of NPMP baseline or background levels of pesticide residues, will provide a basis for comparison of subsequently identified pesticide residue levels in an environmental component and, ultimately, detection of significant trends.

In determining levels and trends of pesticide residues, NPMP personnel have been guided by criteria of the Monitoring Panel of the Federal Working Group on Pest Management (*2*). The Panel has listed five areas of concern for individuals evaluating pesticide residue levels in environmental components. They are: any concentration of a pesticide known to be potentially harmful; increasing trends; levels exceeding standards; recognition of adverse effects on humans; and erratic variability, a statistically oriented observation that is potentially common to each stratum sampled.

This report is a summary of the pesticide application data and soil and crop residue data collected in Fiscal Year 1970 (FY-70) from 1,506 sites located in 35 States. Data were not collected from certain agricultural States because of budgetary limitations. States omitted were those abounding in wheat and other grains, which require fewer pesticides than do many nongrain crops. The FY-69 (*3*) and FY-70 findings have achieved the initial NPMP goal of establishing baseline data. Authors will identify significant trends as more data are accumulated.

Sampling

Sampling techniques involved in this study were generally the same as those employed by Wiersma, Sand, and Cox in a 1971 study (*4*). In FY-70, cropland sites in 35 States were sampled (Fig. 1). This included all but the following States: Alaska, Arizona, Colorado, Hawaii, Idaho, Kansas, Montana, Nevada, New Mex-

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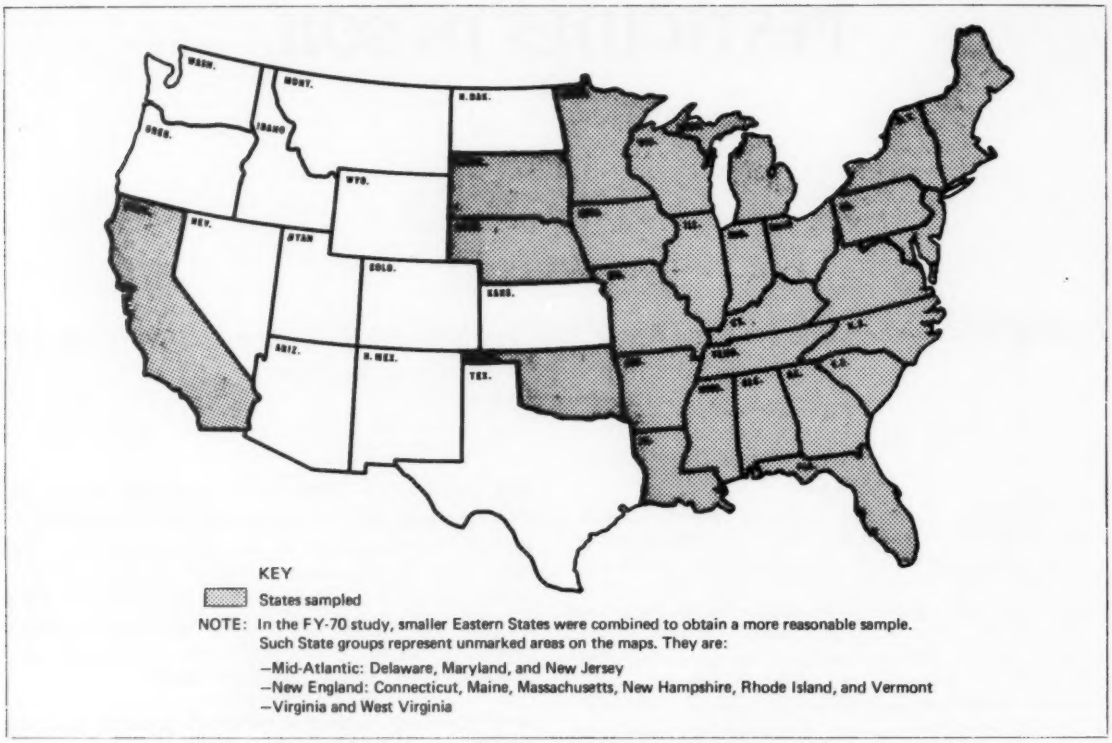
KEY
States sampled
NOTE: In the FY-70 study, smaller Eastern States were combined to obtain a more reasonable sample. Such State groups represent unmarked areas on the maps. They are:
—Mid-Atlantic: Delaware, Maryland, and New Jersey
—New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
—Virginia and West Virginia

FIGURE 1. *States sampled for pesticide residues, FY-70*

ico, North Dakota, Oregon, Texas, Utah, Washington, and Wyoming.

Although an attempt was made to collect soil and crop samples just prior to harvest, this was not always possible. Crop samples were not collected if the crop was not mature and/or ready for harvest.

Analytical Procedures

SOIL

To analyze soil for pesticide residues, a 300-g subsample was taken from a thoroughly mixed field sample. The subsample was dampened with water and extracted with 600 ml of 3:1 hexane:isopropanol solvent by concentric rotation for 4 hours. The isopropanol was removed by three distilled water washes and the hexane extract was dried through anhydrous sodium sulfate. The sample extract was then stored at low temperature for subsequent gas-liquid chromatographic analysis.

CROPS

To analyze crop samples containing less than 2 percent fat (e.g., alfalfa, bur clover, corn stalks, cotton stalks, green bolls, and miscellaneous hay), technicians blended 100-g samples of the crop with 25 ml of distilled water for 3 minutes in 800 ml of acetonitrile. Half the sample extract, containing 50 grams of the original sample, was decanted into a 500-ml Erlenmeyer flask. After concentration under a three-ball Snyder column to approximately 10 ml, 100 ml of hexane was added, and the hexane-acetonitrile azeotrope was again concentrated to 10 ml. This process was carried out three times to remove essentially all the acetonitrile. The hexane extract was dried through anhydrous sodium sulfate, the volume was adjusted to 100 ml, and the extract was stored at low temperature until ready for partitioning.

To analyze crop samples containing more than 2 percent fat (e.g., corn kernels, cottonseeds, and soybeans), researchers prewashed a 100-g sample with 100 ml of isopropanol and then with 100 ml of hexane. Both prewashes were discarded. The sample was dried, dry-blended, added to 100 ml isopropanol, and blended again. After the addition of 300 ml of hexane, the isopropanol was removed by two washes with aqueous NaCl solution and one wash with distilled water. The water-alcohol layers were discarded; the hexane layer was concentrated, adjusted to 100 ml, and held at low temperature for partitioning.

After extraction, all crop samples were partitioned with hexane-acetonitrile as follows: a 50-ml portion of

the hexane sample extract was shaken with 100 ml of acetonitrile in a 500 ml separatory funnel. The bottom acetonitrile layer was set aside. Nanograde acetonitrile (100 ml) was added to the hexane extract and the separation step described above was repeated two more times; then the hexane was discarded and the three acetonitrile layers were combined. The 300-ml acetonitrile extract, which contained essentially all the pesticides in the original hexane extract, was backwashed with 25 ml of acetonitrile-saturated hexane and the hexane layer was discarded. The acetonitrile sample extract was concentrated to approximately 10 ml under a three-ball Snyder column, and 100 ml of hexane was added. Addition of hexane and concentration to approximately 10 ml was performed three times, after which the sample was essentially in hexane. Remaining hexane extract was diluted to appropriate volume and held at low temperature for subsequent florisil column cleanup and fractionation.

GAS-LIQUID CHROMATOGRAPHY

Analyses were performed on gas chromatographs equipped with tritium foil electron affinity detectors for organochlorine compounds and thermionic or flame photometric detectors for organophosphorous compounds. A multiple-column system employing polar and nonpolar columns was utilized to identify and confirm pesticides. Instrument parameters were as follow:

Columns:	Glass, 6 mm o.d. by 4 mm i.d., 183 cm long, packed with one of the following: 9 percent QF-1 on 100/120 mesh Gas-Chrom Q; 3 percent DC-200 on 100/120 mesh Gas-Chrom Q; or 1.5 percent OV-17/1.95 percent QF-1 on 100/120 mesh Sepulcoport.	
Carrier Gases:	5 percent methane-argon at a flow rate of 80 ml/min; prepurified nitrogen at a flow rate of 80 ml/min.	
Temperatures:	Detector	200°C
	Injection port	250°C
	Column QF-1	166°C
	Column DC-200	170-175°C
	Mixed column	185-190°C

Sensitivity or minimum detection levels for organochlorine compounds ranged from 0.002 to 0.03 ppm except for combinations of polychlorinated biphenyls (PCB's), chlordane, toxaphene, and other chemicals which had minimum detectable levels of 0.05 to 0.1 ppm. Minimum detectable levels for organophosphorous compounds were approximately 0.01 to 0.03 ppm. When necessary, residues were confirmed by thin-layer chromatography or p-values.

RECOVERY STUDIES

For organochlorine pesticides, average recovery rate in soil was 90 to 110 percent. Recovery values for stalks and hay ranged from 80 to 95 percent, with an average of 89 percent; corresponding values for grains were 90 to 100 percent, with a 95 percent average. For organophosphate pesticides, average recovery values were 67.1 percent for soybeans, 86 percent for sorghum grain, and 60 percent for corn stalks. Residue levels in both crops and soils are expressed on a dry-weight basis and are corrected for percent recovery.

Results

Tables presented in this report are divided into three groups: pesticides applied to cropland, chlorinated hydrocarbon pesticide residues in cropland soil, and chlorinated hydrocarbon and organophosphate pesticide residues in crops. Pesticide application data are further subdivided by all sites and by State. Residues in soil are summarized by all sites and by States and cropping regions.

Most tables list the number of samples, the number of times a pesticide was applied or detected, percent occurrence of that particular pesticide, arithmetic mean, and range. Readers should exercise caution when interpreting the arithmetic mean because data are not normally distributed. The arithmetic mean tends to be considerably higher than the corresponding median; but because of the skewed distribution of these data, the mean may not be a good indication of central tendency. Hence geometric means and 50 percent estimates have been presented.

PESTICIDES APPLIED TO CROPLAND

When soil samples were collected from cropland, field personnel attempted to contact farmers to determine what pesticides had been applied to the sites during the year of sampling. These data were not always available: only 1,346 use records were collected from 1,506 sites. Tables summarizing application data show the number of sites using a pesticide, percent of sites using a particular pesticide, average rate of application for sites using the pesticide, and average amount of pesticide applied to all sites. The latter figure was determined by dividing the total amount of active ingredients applied to all sites by the total number of sites surveyed. All rate data are expressed in pounds per acre (lb/a). To convert to kilograms per hectares (kg/ha), multiply by 1.1208.

ALL SITES

Table 1 is a summary of the 1,346 sites surveyed from 35 States. The most common pesticides were atrazine, 2,4-D, captan, and malathion, which were used

on 11, 9, 8, and 6 percent of the sites, respectively. Aldrin and DDT were used on 4 percent of the sites.

BY STATE

Table 2 is a breakdown of the all-site data by State. Because some of the smaller Eastern States had very few samples, several were combined to obtain more representative data. State groups used were Mid-Atlantic: Delaware, Maryland, and New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; and Virginia and West Virginia.

Considering the number of States sampled, it is not feasible to discuss pesticide applications of each State. It is, however, worthwhile to mention application frequencies of a few States.

Because Mississippi farmers produce large quantities of cotton, a crop which demands heavy pesticide treatment, they apply a large number of pesticides to much of their cropland. Growers used the following pesticides most frequently on the specified percentage of sites: methyl parathion, 48 percent; trifluralin, 42 percent; DDT, 32 percent; Cotoran (fluometuron), 26 percent; toxaphene, 23 percent; Bidrin (dicrotophos), 19 percent; MSMA, 19 percent; folex, 16 percent; and diuron, 13 percent. In Illinois, a major corn-growing State, pesticides applied most frequently and the percentage of sites treated were: captan, 45 percent; malathion, 45 percent; Ramrod (propachlor), 24 percent; aldrin, 18 percent; atrazine, 16 percent; and heptachlor, 12 percent. In contrast to these States were Oklahoma, Minnesota, Kentucky, and the New England group, where no pesticide was applied to more than 8 percent of the sampling sites.

Herbicide 2,4-D was applied most frequently in South Dakota; of the sites sampled, 25 percent were treated. Atrazine was applied most frequently in Wisconsin and North Carolina: 25 and 26 percent of the sites, respectively, were treated. Captan was applied most frequently in the Mid-Atlantic States; 47 percent of the sites were treated.

BY CROP

Table 3 presents pesticide application data for several crops. The few pesticides applied to alfalfa and bur clover were not widely used. Of the many different pesticides applied to field corn, atrazine, captan, 2,4-D, and malathion were employed most frequently. Farmers used 45 different pesticides on cotton fields; of these compounds, 14 were applied to more than 10 percent of the sites. In contrast, field workers applied only two pesticides to both grass hay and mixed hay fields. Although 27 pesticides were applied to soybeans, only amiben and trifluralin were applied to more than 5 percent of the sites sampled.

CHLORINATED HYDROCARBON PESTICIDE RESIDUES IN CROPLAND SOIL

All 1,506 soil samples from the 35 States were examined for chlorinated hydrocarbon residues. A few samples were analyzed for additional pesticides, but these data were insufficient for consideration. In the future, soil residue analyses will be expanded to include more compounds.

Samples were not analyzed for PCB's because little was known about them at the time of analysis. A review of the gas chromatograph traces revealed that PCB residues were seldom present and, when they were, the residues existed only in very small quantities. PCB peaks were recognized and not confused with DDT.

ALL SITES

Table 4 summarizes chlorinated hydrocarbon soil residue data for all States, including the number of times a pesticide was detected, percent occurrence, arithmetic mean, geometric mean with 95 percent confidence interval, and range of detected residue values. The geometric mean was used because it gives a better indication of the central tendency of the data. It was calculated using a 0.01 addition to eliminate the problem of zeros and was later subtracted from the calculated mean.

The most widely distributed chlorinated hydrocarbon was dieldrin: 31 percent of the soil samples had detectable residues. It was followed by DDTR (DDE+TDE), aldrin, chlordane, and heptachlor epoxide, which were detected at 23, 13, 11, and 10 percent of the sites, respectively.

DDTR existed in the highest concentration, with an arithmetic mean of 0.30 ppm and geometric mean of 0.0116 ppm. Although the arithmetic mean for dieldrin was much lower than that for DDTR, the geometric means are indistinguishable at the 95 percent confidence level. The very high residue value of 113 ppm as shown in the range of DDTR can have a major effect on an arithmetic mean. The effect of extreme values upon the geometric mean is considerably less.

BY STATE

Chlorinated hydrocarbon residues in soils of specific States (Table 5) are presented in the same manner as the all-sites data except for the geometric means.

Comparisons of the percent occurrence of aldrin, dieldrin, heptachlor epoxide, DDTR, and chlordane are presented in Figures 2 through 6. The key for each figure is based on the arithmetic average percent occurrence ($\bar{x}$) of the given pesticide for all sites. The four categories used are: greater than $2\bar{x}$, greater than $\bar{x}$ but less than $2\bar{x}$, greater than $\frac{1}{2}\bar{x}$ but less than $\bar{x}$, and less than $\frac{1}{2}\bar{x}$.

Iowa and Illinois showed the highest percent occurrence of aldrin, dieldrin, and heptachlor epoxide (Fig.

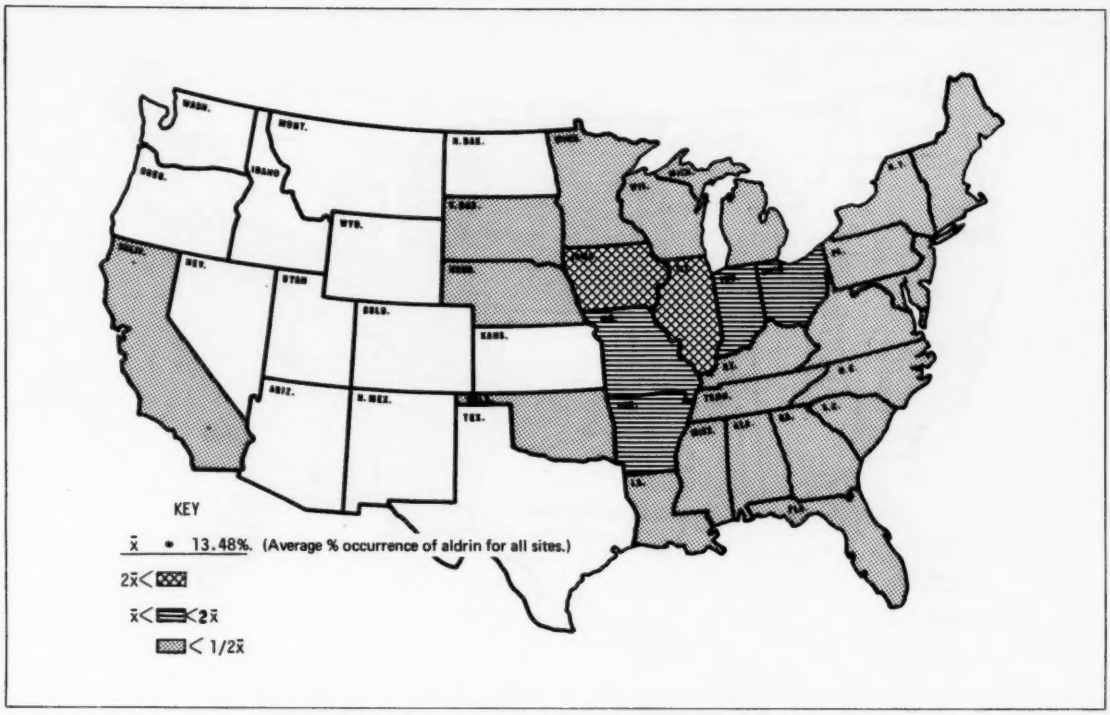

FIGURE 2. *Aldrin residues, %, in cropland soil by State, FY-70*

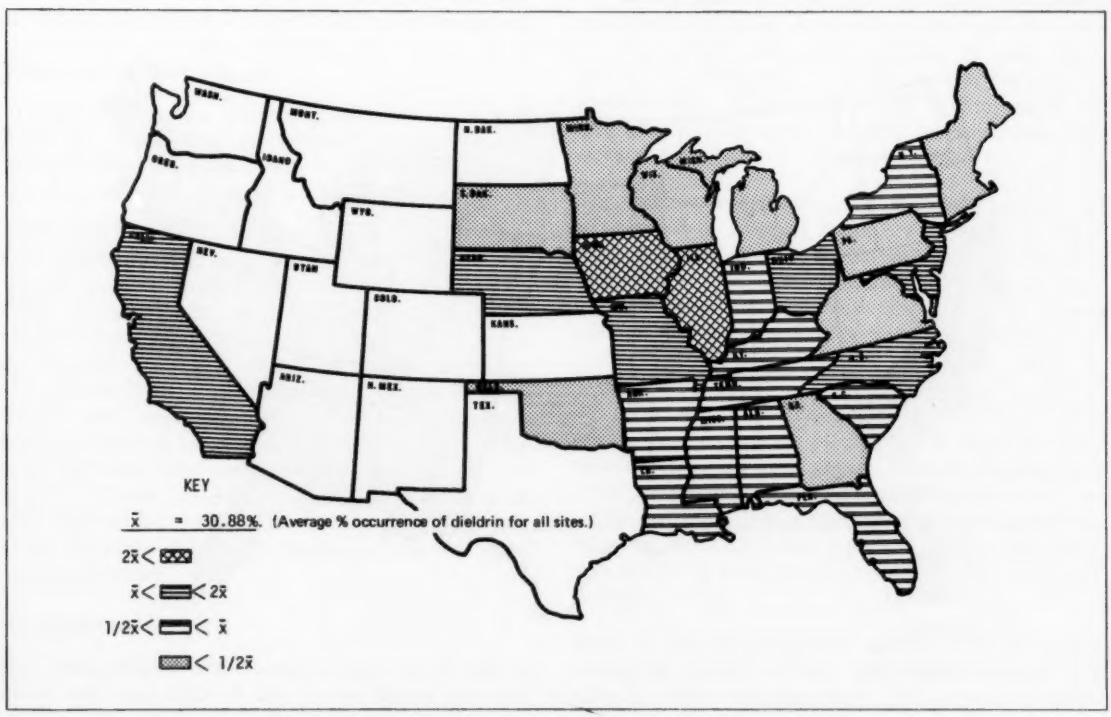

FIGURE 3. *Dieldrin residues, %, in cropland soil by State, FY-70*

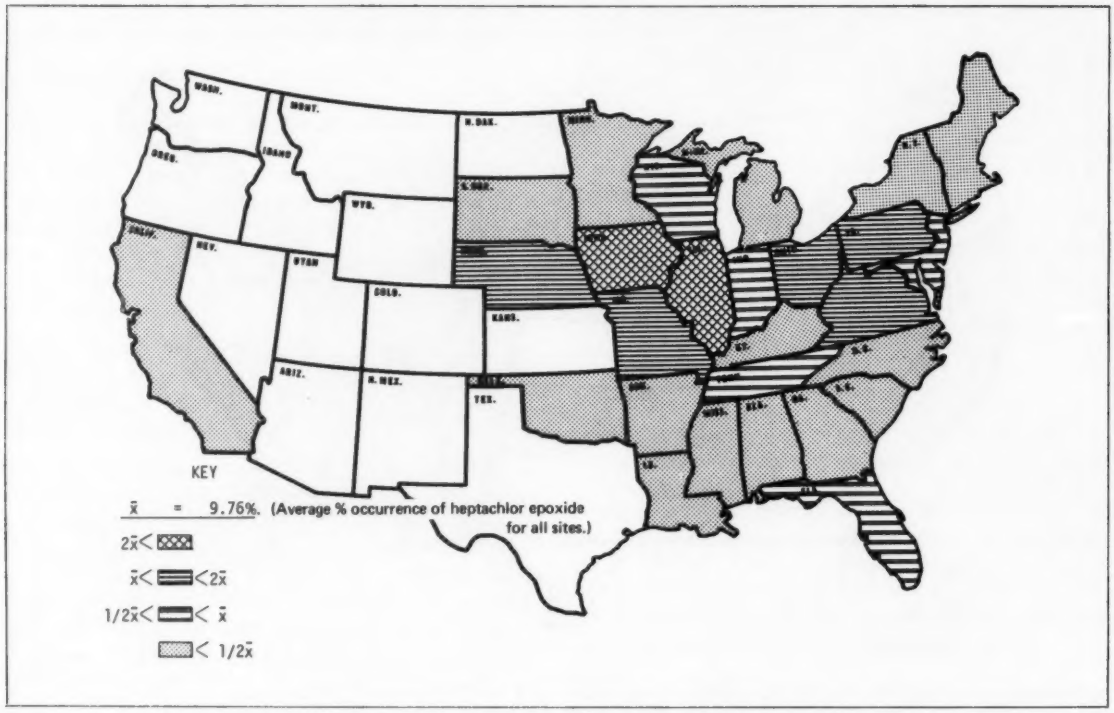

FIGURE 4. *Heptachlor epoxide residues, %, in cropland soil by State, FY-70*

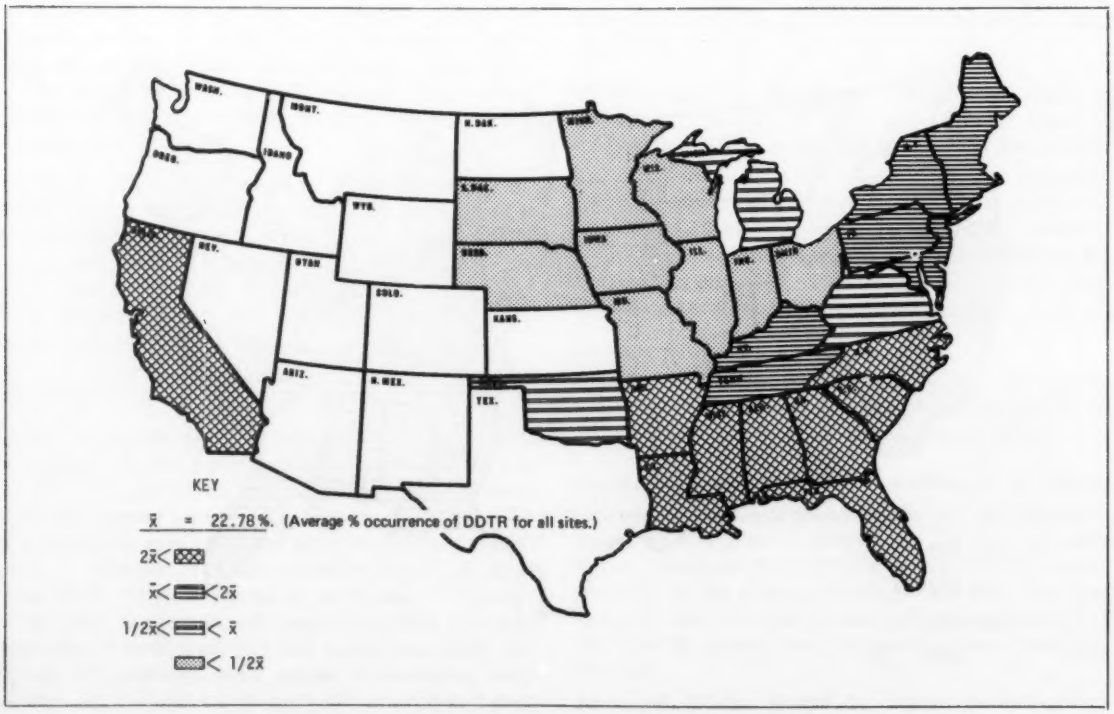

FIGURE 5. *DDTR residues, %, in cropland soil by State, FY-70*

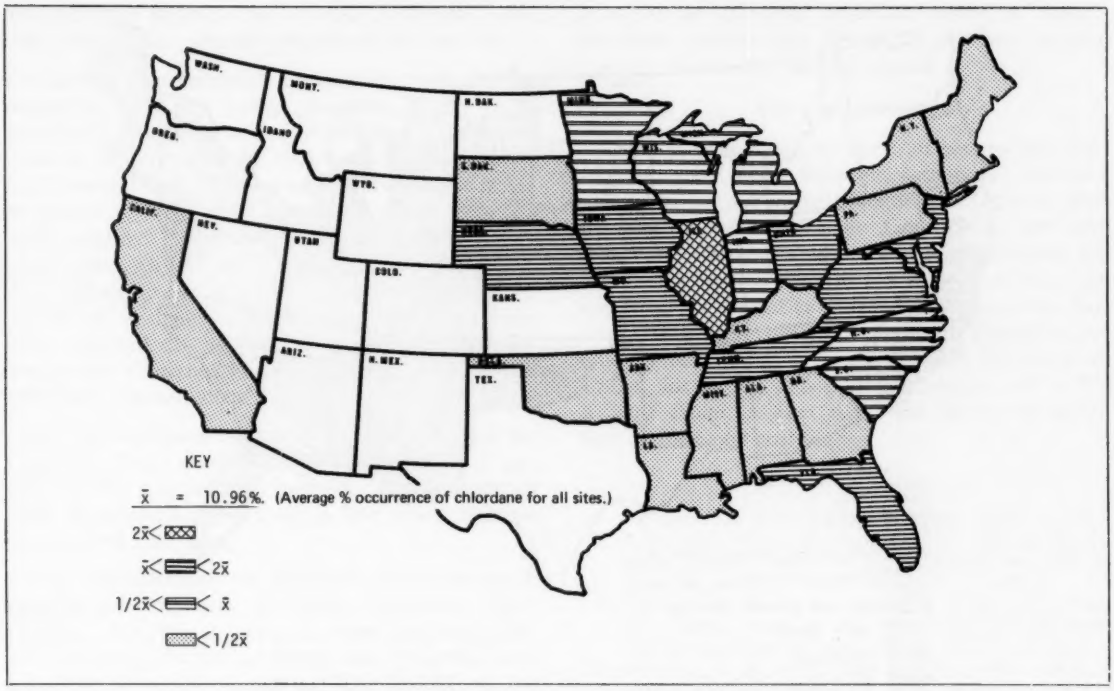

FIGURE 6. *Chlordane residues, %, in cropland soil by State, FY-70*

2-4). DDTR detections were concentrated in Southeastern States and California (Fig. 5); Central States showed low incidence. Chlordane occurred most frequently in Illinois soil samples (Fig. 6).

Michigan, Minnestoa, Oklahoma, and Wisconsin were below the all-sites average detection frequency for all five pesticides. Residue levels in South Dakota were less than half the comparable all-sites figures.

Table 6 lists the 50 percent estimates and 95 percent confidence interval of that estimate, offering a statistical comparison of pesticide residue levels between States. The given values were calculated using a slightly modified regression analysis method described by Daum (*5*). Residue values were ranked from lowest to highest and accumulated; percentages were then computed. Values were transformed to logarithms, percentages were transformed to probits, and the relationship between the logarithms and probits was calculated by regression analysis. Six different detectable residue levels were required for the calculation. When the upper limit of the 95 percent fiducial interval is less than 0.01 ppm, no value is shown.

BY CROPPING REGION

Data were grouped into cropping regions based upon a major land use map of the United States compiled by F. J. Marschner, U.S. Department of Agriculture, Bureau of Agricultural Economics, 1950. The land in the United States was grouped by county into several major land use areas: corn, cotton, fruit, general farming, hay, small grain, and vegetables. In some cases, two areas overlapped: cotton and general farming, for example (Fig. 7). Field personnel determined at the time of sample collection whether land had been irrigated.

The percent occurrence and arithmetic means for soil residues by cropping region are presented in Tables 7 and 8. In the corn region, aldrin, chlordane, and dieldrin residues were widespread and the mean concentrations for these pesticides were also above the all-sites average. Cotton region soils had high DDTR, toxaphene, and trifluralin residues. A greater variety of pesticides was detected in the cotton and general farming region than in the cotton region, but residue values and percent occurrence of comparable pesticides were usually lower. Hay and general farming residues were lower and small-grain soils generally contained the lowest residue levels. The number of sites in irrigated land, vegetable and fruit, and vegetable regions was small; data appear to indicate widespread occurrence of DDT residues.

Table 9 lists the 50 percent estimate and 95 percent confidence interval of that estimate for pesticide residues in soil by cropping region. Using this table makes it possible to determine whether two residue values are significantly different with a risk of less than 5 percent.

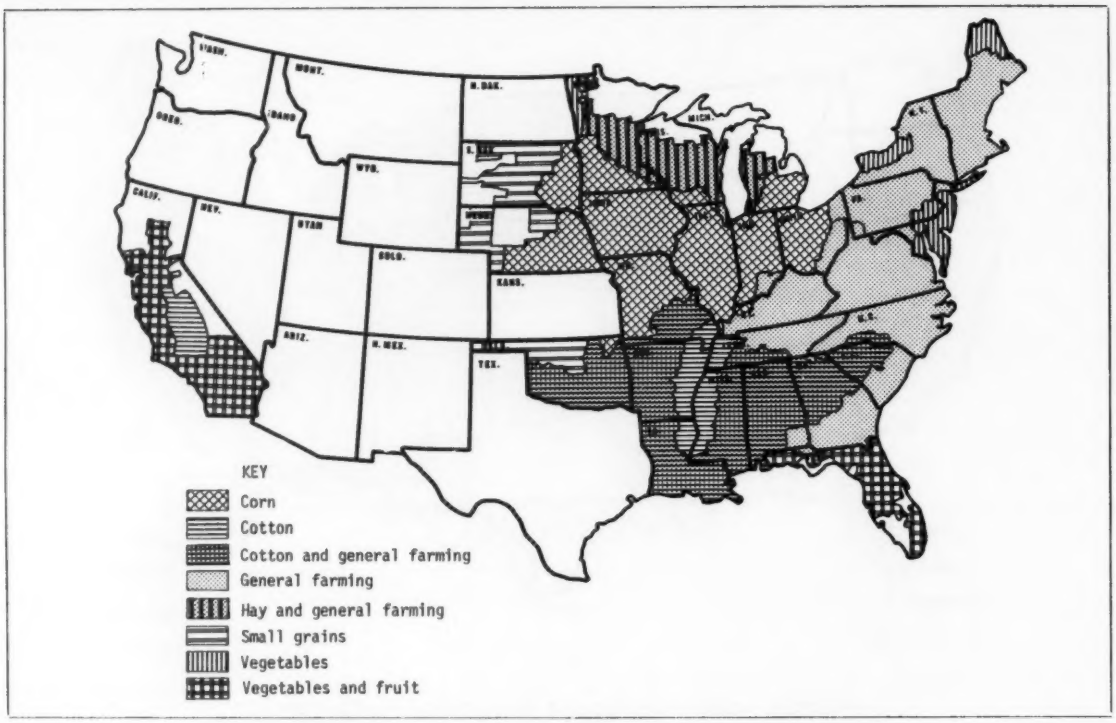

FIGURE 7. *Cropping regions for States sampled, FY-70*

When the confidence interval for DDTR for cotton is higher and does not overlap with the DDTR interval for cotton and general farming, it can be stated that the cotton region has higher DDTR residues in cropland soil than the cotton and general farming region with less than a 5 percent risk.

Table 9 indicates that DDTR residues were found principally in cotton, vegetable and fruit, and irrigated land regions; corn, hay, and vegetable regions were relatively free of this residue. Significantly high dieldrin residues were associated with corn and irrigated land regions.

BY CROP

Pesticide residues in soil have also been grouped according to crops grown on the soil (Table 10). The few minor discrepancies between the number of sites examined in Tables 3 and 10 are due to lost samples.

Soils under alfalfa and bur clover contained a number of low-level pesticide residues. Field corn soils showed detectable levels of dieldrin at 42 percent of the sites. Soil in cotton fields averaged over 2 ppm DDTR. Although very few pesticides were applied to grass hay or mixed hay sites, the occurrence of detectable residues of dieldrin and DDTR was surprisingly high. Dieldrin was the residue found most commonly in soybean soils, but DDTR was the residue in highest concentration.

CHLORINATED HYDROCARBON AND ORGANOPHOSPHATE PESTICIDE RESIDUES IN CROPS

As mentioned earlier, crop samples were collected only from crops which were ripe and/or ready for harvest. They were taken directly from the field and were collected whenever available. In total, 952 samples were collected from about 640 sites. All crop samples were analyzed for chlorinated hydrocarbon pesticides. In addition, samples were analyzed for organophosphates when use records indicated they had been applied. The organophosphate sample is thus biased and could be expected to yield higher residue values for any given crop than would have resulted had all samples been analyzed.

Alfalfa and bur clover samples contained DDTR 28 percent of the time (Table 11); chlordane and dieldrin were detected less frequently. Most of these samples were analyzed for organophosphate residues; no such residues were detected.

Field corn kernels were exceptionally free of both chlorinated hydrocarbon and organophosphate pesticide residues. However, pesticide residues in field corn stalks were detected considerably more often. DDTR, dieldrin,

and chlordane occurred 20, 16, and 5 percent of the time, respectively; detected concentrations were low.

Cottonseeds were frequently contaminated with DDTR, toxaphene, DEF, and methyl parathion. Cotton stalks contained high concentrations of pesticides: DDTR was found in 91 percent of the stalk samples with an average concentration of 3.81 ppm; toxaphene occurred in 45 percent of the samples and averaged 6.96 ppm; dieldrin occurred frequently, but the residue levels were much lower. Of the 18 sites where organophosphates were applied to cotton, methyl parathion occurred 50 percent of the time. DEF, malathion, and ethyl parathion occurred 39, 22, and 17 percent of the time, respectively. Concentrations of both ethyl parathion and DEF were relatively high.

Grass hay contained a number of pesticides, but the frequency of any single pesticide was less than 11 percent. DDTR was the only pesticide with a significant level of occurrence, but even it had a low average-residue level: 0.07 ppm.

Mixed hay contained no detectable organophosphate residues, but frequently contained chlorinated hydrocarbons. DDTR was again the most prevalent pesticide, occurring 69 percent of the time. Chlordane and toxaphene were also found but, like DDTR, at low concentrations.

Soybeans showed traces of dieldrin in 39 percent of the samples, but no pesticide exceeded an average concentration of 0.03 ppm. Soybeans showed no organophosphate residues even though all 137 sites sampled had been treated with such pesticides.

Acknowledgments

It is not possible to list by name all persons who contributed to this study. However, authors are especially grateful to the staff at the Monitoring Laboratory, Mississippi Test Facility, Bay St. Louis, Miss., who processed and analyzed samples for chemical residues and contributed immeasurably to this study, and to inspectors from the Animal and Plant Health Inspection Service, USDA, who collected the samples. Finally, recognition is due Dr. Edwin Cox, Biometrical Services Staff, USDA, for sample allocation procedures, and to Dr. Richard Daum, Animal and Plant Health Inspection Service, for probit analyses.

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TABLE 1. *Summary of pesticides applied to cropland, all sites,[1] FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[2]	Arith. Mean (lb/a)[2]
Aldrin	57	4.23	1.03	0.0434
Amiben	51	3.79	1.77	0.0669
Amitrole	1	0.07	2.11	0.0016
Atrazine	154	11.44	1.74	0.1987
Azinphosmethyl	15	1.11	4.19	0.0467
Azodrin (monocrotophos)	6	0.45	4.28	0.0191
Barban	1	0.07	0.20	0.0001
Benefin	2	0.15	1.31	0.0019
Bidrin (dicrotophos)	8	0.59	0.31	0.0018
Borax	2	0.15	1.25	0.0019
Bordeaux mixtures	1	0.07	1.00	0.0007
Buturon	2	0.15	0.01	0.0000
Bux-ten (bux)	16	1.19	2.27	0.0269
Calcium arsenate	1	0.07	9.80	0.0073
Captan	106	7.88	1.68	0.1323
Carbaryl	31	2.30	3.91	0.0900
Carbophenothion	3	0.22	0.92	0.0020
CDAA	1	0.07	0.60	0.0004
CDEA	1	0.07	2.00	0.0015
Ceresan L	3	0.22	0.04	0.0001
Ceresan M (granosan)	8	0.59	0.02	0.0001
Ceresan red	19	1.41	0.03	0.0004
Chevron RE-5353	1	0.07	0.70	0.0005
Chlordane	1	0.07	1.00	0.0007
Chlorobenzilate	3	0.22	0.95	0.0021
Chloroneb	5	0.37	0.01	0.0000
Chloroxuron	3	0.22	1.42	0.0032
CIPC (chloropropham)	1	0.07	0.66	0.0005
Copper oxide	3	0.22	3.70	0.0082
Copper-8-quinolinolate	1	0.07	0.01	0.0000
Copper sulfate	9	0.67	56.65	0.3788
Cotoran (fluometuron)	15	1.11	0.68	0.0076
2,4-D	122	9.06	0.64	0.0578
DAC	3	0.22	3.50	0.0078
Dalapon	10	0.74	2.55	0.0189

(Continued next page)

TABLE 1 (cont'd). *Summary of pesticides applied to cropland, all sites,[1] FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Appl. Rate Arith. Mean (lb/a)[2]	Arith. Mean (lb/a)[2]
2,4-DB	7	0.52	0.56	0.0029
DDT	37	3.75	5.20	0.1428
DEF	6	0.45	1.44	0.0064
Demeton	2	0.15	0.88	0.0013
Diazinon	11	0.82	1.95	0.0160
Dicamba	2	0.15	0.04	0.0001
Dichloropropane	1	0.07	26.00	0.0193
Dichloropropene	2	0.15	64.21	0.0954
Dichlorprop	1	0.07	0.50	0.0004
Dicofol	4	0.30	1.95	0.0058
Dieldrin	5	0.37	0.21	0.0008
Dimethoate	2	0.15	3.21	0.0048
Dinitrobutylphenol	6	0.45	2.84	0.0126
Dinitrocresol	2	0.15	0.10	0.0002
Dinitrocyclohexylphenol	1	0.07	0.50	0.0004
Dioxathion	1	0.07	0.75	0.0006
Diphenamid	2	0.15	3.00	0.0045
Disulfoton	11	0.82	0.62	0.0050
Dithane M-45 (mancozeb)	1	0.07	1.50	0.0011
Diuron	8	0.59	0.47	0.0028
Dodine	3	0.22	5.23	0.0117
DSMA	6	0.45	2.02	0.0090
Endosulfan (I)	3	0.22	0.61	0.0014
Endothall	1	0.07	0.90	0.0007
Endrin	6	0.45	2.28	0.0102
EPN	2	0.15	1.10	0.0016
EPTC	5	0.37	22.10	0.0821
Ethion	8	0.59	2.13	0.0126
Ethylene dibromide	1	0.07	0.01	0.0000
Falone	1	0.07	2.00	0.0015
Fensulfothion	4	0.30	1.20	0.0036
Fenthion	1	0.07	0.09	0.0001
Ferbam	1	0.07	4.60	0.0034
Folex	7	0.52	1.30	0.0068
Furadan (carbofuran)	1	0.07	1.00	0.0007
Heptachlor	20	1.49	0.79	0.0118
Isopestox	1	0.07	0.01	0.0000
Lasso	13	0.97	1.01	0.0098
Lead arsenate	1	0.07	6.40	0.0048
Lindane	4	0.30	0.01	0.0000
Linuron	15	1.11	0.86	0 0096
Malathion	84	6.24	0.19	0.0117
Maleic hydrazide	3	0.22	1.80	0.0040
Maneb	2	0.15	1.00	0.0015
MCPA	10	0.74	0.66	0.0049
Methoxychlor	22	1.63	0.12	0.0020
Methyl demeton	2	0.15	1.13	0.0017
Methylmercury dicyandiamide	14	1.04	0.01	0.0001
Methyl trithion	2	0.15	7.75	0.0115
Mevinphos	2	0.15	0.10	0.0001
Mirex	1	0.07	0.01	0.0000
Monuron	2	0.15	0.31	0.0005
MSMA	13	0.97	1.79	0.0173
Nitralin	7	0.52	0.75	0.0039
Nitrate	7	0.52	51.71	0.2689
Norea	2	0.15	1.00	0.0015
NPA	6	0.45	2.02	0.0090
Paraquat	6	0.45	0.18	0.0008
Parathion, ethyl	20	1.49	3.41	0.0507
Parathion, methyl	44	3.27	4.16	0.1360
PCNB	3	0.22	0.01	0.0000
Phorate	19	1.41	3.17	0.0447
Picloram	1	0.07	1.00	0.0007
Prometryne	1	0.07	0.75	0.0006
Propanil	3	0.22	2.83	0.0063
Ramrod (propachlor)	45	3.34	1.47	0.0493
Silvex	5	0.37	0.64	0.0024
Simazine	5	0.37	2.66	0.0099
Sodium chlorate	5	0.37	6.40	0.0238
Strobane	1	0.07	3.00	0.0022
Sulfur	16	1.19	50.74	0.6032
Sutan	5	0.37	3.95	0.0147
2,4,5-T	1	0.07	2.00	0.0015
TCA	2	0.15	5.25	0.0078
TDE	6	0.45	2.38	0.0106
Terbacil	2	0.15	0.39	0.0006
Tetradifon	1	0.07	0.75	0.0006
Thiram	7	0.52	0.02	0.0001
Toxaphene	33	2.45	9.54	0.2339
Trifluralin	47	3.49	0.94	0.0330
Vernolate	7	0.52	2.90	0.0151

[1] 1,346 sites, 35 States.

[2] To convert lb/a to kg/ha., multiply by 1.1208.

TABLE 2. *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Alabama, 22 Sites				
Azinphosmethyl	1	4.55	4.00	0.1818
Azodrin	1	4.55	12.00	0.5455
Copper sulphate	1	4.55	8.00	0.3636
Cotoran	2	9.09	1.50	0.1364
DDT	6	27.27	11.08	3.0227
DEF	1	4.55	1.50	0.0682
DSMA	1	4.55	2.00	0.0909
Endothall	1	4.55	0.90	0.0409
Endrin	1	4.55	10.50	0.4773
Nitralin	2	9.09	1.00	0.0909
Parathion, ethyl	3	13.64	16.06	2.1900
Parathion, methyl	7	31.82	6.54	2.0823
Strobane	1	4.55	3.00	0.1364
Sulfur	1	4.55	72.00	3.2727
Toxaphene	3	13.64	48.31	6.5873
Trifluralin	3	13.64	2.03	0.2773
Arkansas, 47 Sites				
Aldrin	1	2.13	0.01	0.0002
Amiben	2	4.26	1.00	0.0428
Azodrin	1	2.13	3.75	0.0798
Captan	2	4.26	0.03	0.0015
Carbaryl	3	6.38	1.70	0.1085
Ceresan M	2	4.26	0.05	0.0023
Ceresan red	2	4.26	0.10	0.0043
Chloroneb	3	6.38	0.01	0.0009
Cotoran	2	4.26	0.77	0.0330
Dalapon	1	2.13	3.00	0.0638
2,4-DB	2	4.26	0.50	0.0213
DDT	2	4.26	6.25	0.2660
DEF	1	2.13	0.75	0.0160
Dinitrobutylphenol	1	2.13	10.00	0.2128
Dinitrocyclohexylphenol	1	2.13	0.50	0.0106
DSMA	1	2.13	1.00	0.0213
EPN	1	2.13	0.50	0.0106
Ethylene dibromide	1	2.13	0.01	0.0002
Folex	2	4.26	1.50	0.0638
Lasso	1	2.13	0.50	0.0106
Linuron	1	2.13	1.50	0.0319
Methylmercury dicyandiamide	3	6.38	0.01	0.0006
Methyl trithion	1	2.13	5.50	0.1170
Monuron	1	2.13	0.25	0.0053
MSMA	3	6.38	3.33	0.2128
Nitralin	2	4.26	0.44	0.0187
Norea	1	2.13	1.00	0.0213
Paraquat	1	2.13	0.25	0.0053
Parathion, methyl	10	21.28	4.00	0.8511
Phorate	1	2.13	0.50	0.0106
Prometryne	1	2.13	0.75	0.1600
Propanil	1	2.13	2.50	0.0532
Toxaphene	2	4.26	1.75	0.0745
Trifluralin	9	19.15	0.68	0.1311
California, 43 Sites				
Azinphosmethyl	3	6.98	0.92	0.0640
Azodrin	2	4.65	4.38	0.2035
Bidrin	1	2.33	0.75	0.0174
Bordeaux mixtures	1	2.33	1.00	0.0233
Carbaryl	1	2.33	1.25	0.0291
Carbophenothion	1	2.33	0.50	0.0116
Chlorobenzilate	1	2.33	1.00	0.0233
2,4-D	1	2.33	0.88	0.0205
DAC	1	2.33	4.00	0.0930
DDT	3	6.98	3.00	0.2093
DEF	1	2.33	3.00	0.0698
Diazinon	1	2.33	2.00	0.0465
Dicofol	2	4.65	0.88	0.0407
Dimethoate	1	2.33	0.33	0.0077
Dioxathion	1	2.33	0.75	0.0174
Disulfoton	1	2.33	1.00	0.0233
DSMA	1	2.33	2.00	0.0465
Endosulfan (I)	2	4.65	0.88	0.0407
Endrin	1	2.33	0.75	0.0174
Ethion	2	4.65	1.50	0.0698
Fenthion	1	2.33	0.09	0.0021
Malathion	2	4.65	2.02	0.0942
Methyl demeton	1	2.33	0.25	0.0058
Paraquat	2	4.65	0.18	0.0086
Parathion, ethyl	7	16.28	0.99	0.1616
Parathion, methyl	1	2.33	0.10	0.0023
Simazine	2	4.65	3.30	0.1535
Sodium chlorate	3	6.98	8.17	0.5698

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TABLE 2 (cont'd). *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Sulfur	5	11.63	41.71	4.8502
Tetradifon	1	2.33	0.75	0.0174
Toxaphene	3	6.98	6.00	0.4186
Trifluralin	1	2.33	2.00	0.0465
Florida, 18 Sites				
Aldrin	1	5.56	4.44	0.2467
Atrazine	1	5.56	0.50	0.0278
Carbaryl	1	5.56	5.00	0.2778
Carbophenothion	2	11.11	1.13	0.1250
Chlorobenzilate	2	11.11	0.92	0.1022
Copper oxide	2	11.11	4.65	0.5167
2,4-D	1	5.56	2.00	0.1111
Dalapon	1	5.56	2.00	0.1111
Dicofol	1	5.56	2.00	0.1111
Dimethoate	1	5.56	6.10	0.3389
Ethion	5	27.78	2.30	0.6389
Lead arsenate	1	5.56	6.40	0.3556
Parathion, ethyl	2	11.11	3.55	0.3944
Sulfur	4	22.22	60.65	13.4778
2,4,5-T	1	5.56	2.00	0.1111
Toxaphene	1	5.56	4.00	0.2222
Georgia, 30 Sites				
Atrazine	2	6.67	2.70	0.1800
Azodrin	1	3.33	0.60	0.0200
Benefin	2	6.67	1.31	0.0873
Bidrin	1	3.33	0.30	0.0100
Calcium arsenate	1	3.33	9.80	0.3267
Captan	8	26.67	0.05	0.0147
Carbaryl	5	16.67	4.45	0.7417
Ceresan red	4	13.33	0.01	0.0013
Copper sulfate	8	26.67	62.73	16.7283
DDT	7	23.33	3.96	0.9233
Dinitrobutylphenol	2	6.67	1.50	0.1000
Disulfoton	1	3.33	0.80	0.0267
Dithane M-45	1	3.33	1.50	0.0500
DSMA	1	3.33	0.50	0.0167
Endrin	1	3.33	0.33	0.0110
Falone	1	3.33	2.00	0.0667
Linuron	1	3.33	1.00	0.0333
Malathion	4	13.33	0.01	0.0013
Methoxychlor	4	13.33	0.03	0.0040
Methyl trithion	1	3.33	10.00	0.3333
Mirex	1	3.33	0.01	0.0003
Parathion, methyl	2	6.67	1.02	0.0683
Simazine	1	3.33	2.50	0.0833
Sulfur	3	10.00	20.00	2.0000
Toxaphene	7	23.33	4.63	1.0800
Trifluralin	1	3.33	1.50	0.0500
Vernolate	5	16.67	2.20	0.3667
Illinois, 51 Sites [2]				
Aldrin	9	17.65	0.92	0.1627
Amiben	5	9.80	2.60	0.2549
Atrazine	8	15.69	1.94	0.3049
Bux-ten (bux)	4	7.84	2.97	0.2333
Captan	23	45.10	0.03	0.0122
Carbaryl	1	1.96	2.00	0.0392
Ceresan red	2	3.92	0.01	0.0004
2,4-D	3	5.88	0.31	0.0182
DAC	1	1.96	1.50	0.0294
Dalapon	1	1.96	1.00	0.0196
Diazinon	2	3.92	0.50	0.0198
Dicamba	1	1.96	0.02	0.0004
Furadan	1	1.96	1.00	0.0196
Heptachlor	6	11.76	0.84	0.0984
Lasso	1	1.96	1.40	0.0275
Linuron	1	1.96	1.00	0.0196
Malathion	23	45.10	0.01	0.0045
Methoxychlor	5	9.80	0.01	0.0010
Phorate	1	1.96	0.05	0.0010
Ramrod	12	23.53	1.23	0.2904
Silvex	1	1.96	0.50	0.0098
Vernolate	1	1.96	1.30	0.0255
Indiana, 77 Sites				
Aldrin	7	9.09	0.82	0.0742
Amiben	6	7.79	0.97	0.0756
Atrazine	13	16.88	1.37	0.2318
Captan	11	14.29	0.01	0.0016
Ceresan red	1	1.30	0.02	0.0003
2,4-D	9	11.69	0.66	0.0769

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TABLE 2 (cont'd). *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Dinitrobutylphenol	1	1.30	2.00	0.0260
Heptachlor	2	2.60	0.76	0.0199
Lasso	5	6.49	1.40	0.0909
Linuron	2	2.60	1.05	0.0273
Malathion	6	7.79	0.01	0.0008
Methoxychlor	2	2.60	0.01	0.0003
Methylmercury dicyandiamide	1	1.30	0.01	0.0001
MSMA	1	1.30	4.00	0.0519
NPA	1	1.30	4.00	0.0519
Ramrod	4	5.19	2.06	0.1071
Trifluralin	1	1.30	1.00	0.0130
Iowa, 152 Sites				
Aldrin	15	9.87	0.83	0.0820
Amiben	14	9.21	0.84	0.0776
Atrazine	24	15.79	1.50	0.2367
Bux-ten (bux)	8	5.26	0.99	0.0520
Captan	2	1.32	0.01	0.0001
Carbaryl	1	0.66	1.60	0.0105
Chevron RE-5353	1	0.66	0.70	0.0046
CIPC	1	0.66	0.66	0.0043
2,4-D	17	11.18	0.60	0.0669
2,4-DB	2	1.32	0.88	0.0115
Diazinon	3	1.97	0.50	0.0099
Fensulfothion	2	1.32	1.38	0.0181
Heptachlor	5	3.29	0.61	0.0199
Lasso	3	1.97	0.91	0.0180
Lindane	1	0.66	0.02	0.0001
Linuron	1	0.66	0.60	0.0039
NPA	1	0.66	1.00	0.0066
Parathion,ethyl	1	0.66	0.02	0.0001
Phorate	7	4.61	0.85	0.0391
Ramrod	11	7.24	1.37	0.0991
Sutan	2	1.32	4.50	0.0592
Trifluralin	3	1.97	0.40	0.0079
Kentucky, 31 Sites				
Amiben	2	6.45	2.00	0.1290
Atrazine	2	6.45	1.75	0.1129
Chloroxuron	1	3.23	2.00	0.0645
2,4-D	2	6.45	0.88	0.0565
Dalapon	1	3.23	1.00	0.0323
Louisiana, 25 Sites				
Aldrin	3	12.00	0.10	0.0124
Azinphosmethyl	3	12.00	1.18	0.1420
Buturon	2	8.00	0.01	0.0008
Captan	1	4.00	0.02	0.0008
Ceresan L	2	8.00	0.01	0.0008
Cotoran	1	4.00	1.00	0.0400
2,4-D	4	16.00	0.88	0.1400
Dalapon	3	12.00	3.67	0.4400
2,4-DB	1	4.00	0.75	0.0300
DDT	2	8.00	2.50	0.2000
DEF	1	4.00	1.12	0.0448
Diuron	1	4.00	0.70	0.0280
DSMA	1	4.00	6.00	0.2400
Norea	1	4.00	1.00	0.0400
NPA	1	4.00	2.00	0.0800
Parathion, methyl	6	24.00	3.54	0.8500
Propanil	2	8.00	3.00	0.2400
Silvex	2	8.00	0.75	0.0600
TCA	2	8.00	5.25	0.4200
TDE	1	4.00	6.00	0.2400
Terbacil	2	8.00	0.39	0.0316
Toxaphene	3	12.00	6.33	0.7600
Trifluralin	4	16.00	0.81	0.1300
Michigan, 34 Sites				
Atrazine	4	11.76	3.38	0.3971
Azinphosmethyl	3	8.82	3.75	0.3309
Captan	2	5.88	13.00	0.7647
Carbaryl	2	5.88	15.00	0.8824
CDEA	1	2.94	2.00	0.0588
Chlordane	1	2.94	1.00	0.0294
2,4-D	3	8.82	1.17	0.1029
Dodine	2	5.88	2.22	0.1309
EPTC	2	5.88	3.50	0.2059
Ethion	1	2.94	2.50	0.0735
Ferbam	1	2.94	4.60	0.1353
Malathion	1	2.94	3.75	0.1103
Simazine	1	2.94	2.00	0.0588
Sulfur	2	5.88	97.50	5.7353

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TABLE 2 (cont'd). *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Mid-Atlantic States,[8] 15 Sites				
Aldrin	1	6.67	1.20	0.0800
Atrazine	2	13.33	1.28	0.1707
Azinphosmethyl	1	6.67	0.05	0.0033
Captan	7	46.67	0.02	0.0107
2,4-D	3	20.00	0.77	0.1533
EPTC	1	6.67	100.00	6.6667
Heptachlor	1	6.67	0.04	0.0027
Lasso	1	6.67	0.20	0.0133
Linuron	1	6.67	0.15	0.0100
Malathion	4	26.67	0.01	0.0027
Maneb	1	6.67	2.00	0.1333
Methoxychlor	2	13.33	0.01	0.0013
Methyl demeton	1	6.67	2.00	0.1333
Phorate	1	6.67	20.00	1.3333
Simazine	1	6.67	2.20	0.1467
Minnesota, 119 Sites				
Amiben	4	3.36	2.00	0.0672
Atrazine	6	5.04	1.90	0.0958
Bux-ten (bux)	1	0.84	4.00	0.0336
Captan	2	1.68	0.01	0.0002
Carbaryl	2	1.68	1.45	0.0244
2,4-D	10	8.40	0.74	0.0626
Dalapon	1	0.84	1.00	0.0084
Isopestox	1	0.84	0.01	0.0001
Lasso	1	0.84	1.00	0.0084
Linuron	1	0.84	2.50	0.0210
Malathion	1	0.84	0.01	0.0001
MCPA	7	5.88	0.86	0.0504
Phorate	2	1.68	10.50	0.1765
Ramrod	7	5.88	1.94	0.1143
Silvex	1	0.84	0.40	0.0034
Mississippi, 31 Sites				
Azinphosmethyl	1	3.23	3.00	0.0968
Bidrin	6	19.35	0.23	0.0452
Captan	1	3.23	0.01	0.0003
Carbaryl	2	6.45	4.50	0.2903
Ceresan red	3	9.68	0.01	0.0010
Chloroneb	2	6.45	0.01	0.0006
Cotoran	8	25.81	0.38	0.0977
DDT	10	32.26	6.22	2.0081
DEF	2	6.45	1.13	0.0726
Dinitrobutylphenol	1	3.23	0.52	0.0168
Dinitrocresol	2	6.45	0.10	0.0068
Disulfoton	3	9.68	0.02	0.0016
Diuron	4	12.90	0.13	0.0171
DSMA	1	3.23	0.62	0.0200
Endrin	1	3.23	1.65	0.0532
EPN	1	3.23	1.70	0.0548
Folex	5	16.13	1.22	0.1968
Lasso	1	3.23	0.35	0.0113
Linuron	2	6.45	0.79	0.0510
Monuron	1	3.23	0.38	0.0123
MSMA	6	19.35	0.71	0.1384
Nitralin	2	6.45	0.88	0.0565
NPA	1	3.23	0.26	0.0084
Paraquat	3	9.68	0.16	0.0152
Parathion, methyl	15	48.39	4.82	2.3342
PCNB	1	3.23	0.01	0.0003
Sodium chlorate	1	3.23	3.00	0.0968
Toxaphene	7	22.58	11.86	2.6774
Trifluralin	13	41.94	0.98	0.4113
Missouri, 81 Sites				
Aldrin	10	12.35	1.00	0.1235
Amiben	5	6.17	1.35	0.0833
Atrazine	17	20.99	1.83	0.3840
Carbaryl	1	1.23	2.00	0.0247
2,4-D	9	11.11	0.58	0.0648
Diazinon	1	1.23	0.60	0.0074
Diuron	3	3.70	0.83	0.0309
Heptachlor	1	1.23	1.00	0.0123
Linuron	2	2.47	0.50	0.0123
Ramrod	3	3.70	1.52	0.0562
Sutan	1	1.23	4.00	0.0494
Trifluralin	5	6.17	0.85	0.0525
Nebraska, 106 Sites				
Aldrin	1	0.94	0.50	0.0047
Amiben	2	1.89	0.63	0.0118
Atrazine	16	15.09	1.28	0.1937

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TABLE 2 (cont'd). *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Bux-ten (bux)	2	1.89	1.22	0.0231
Captan	18	16.98	0.01	0.0017
Carbaryl	1	0.94	1.60	0.0151
Ceresan L	1	0.94	0.10	0.0009
2,4-D	9	8.49	0.60	0.0509
Dalapon	1	0.94	2.50	0.0236
Demeton	1	0.94	0.25	0.0024
Diazinon	1	0.94	0.22	0.0021
Dieldrin	1	0.94	0.01	0.0001
Disulfoton	3	2.83	1.14	0.0324
Endrin	2	1.89	0.22	0.0042
Fensulfothion	2	1.89	1.03	0.0195
Heptachlor	2	1.89	0.01	0.0002
Malathion	18	16.98	0.01	0.0017
Methoxychlor	2	1.89	0.01	0.0002
Methylmercury dicyandiamide	1	0.94	0.01	0.0001
Phorate	6	5.66	0.95	0.0540
Ramrod	4	3.77	1.09	0.0410
Thiram	3	2.83	0.01	0.0003
New England,[4] 18 Sites				
No pesticides applied				
New York, 35 Sites				
Atrazine	5	14.29	2.00	0.2857
Azinphosmethyl	1	2.86	37.50	1.0714
Captan	5	14.29	30.01	4.2869
Carbaryl	3	8.57	8.33	0.7143
2,4-D	4	11.43	0.63	0.0726
Demeton	1	2.86	1.50	0.0429
Dichlorprop	1	2.86	0.50	0.0143
Dicofol	1	2.86	4.04	0.1154
Dieldrin	1	2.86	0.02	0.0006
Dodine	1	2.86	11.25	0.3214
EPTC	1	2.86	3.00	0.0857
Malathion	4	11.43	0.01	0.0011
Methoxychlor	3	8.57	0.01	0.0009
Methylmercury dicyandiamide	2	5.71	<0.01	0.0003
Nitrate	7	20.00	51.71	10.3429
Sutan	1	2.86	3.75	0.1071
Thiram	1	2.86	0.10	0.0029
North Carolina, 31 Sites				
Amiben	1	3.23	2.00	0.0645
Atrazine	8	25.81	2.20	0.5677
Azodrin	1	3.23	0.60	0.0194
Captan	1	3.23	0.01	0.0003
Carbaryl	3	9.68	1.32	0.1274
Ceresan red	2	6.45	0.10	0.0065
Copper oxide	1	3.23	1.80	0.0581
Copper-8-quinolinolate	1	3.23	0.01	0.0003
2,4-D	3	9.68	0.83	0.0806
DDT	4	12.90	1.60	0.2065
Diazinon	2	6.45	3.58	0.2310
Dichloropropane	1	3.23	26.00	0.8387
Dichloropropene	2	6.45	64.21	4.1426
Dinitrobutylphenol	1	3.23	1.50	0.0484
Diphenamid	2	6.45	3.00	0.1935
Endosulfan (I)	1	3.23	0.08	0.0026
Lindane	1	3.23	0.01	0.0003
Malathion	1	3.23	2.50	0.0806
Maleic hydrazide	3	9.68	1.80	0.1742
MSMA	2	6.45	2.38	0.1532
Parathion, ethyl	2	6.45	0.60	0.0387
Sulfur	1	3.23	33.75	1.0887
TDE	4	12.90	1.33	0.1710
Thiram	1	3.23	0.01	0.0003
Toxaphene	1	3.23	2.00	0.0645
Ohio, 69 Sites				
Aldrin	6	8.70	1.67	0.1449
Amiben	8	11.59	1.55	0.1801
Atrazine	12	17.39	1.70	0.2955
Captan	1	1.45	0.01	0.0001
CDAA	1	1.45	0.60	0.0087
2,4-D	9	13.04	0.71	0.0920
Dicamba	1	1.45	0.06	0.0009
Dieldrin	1	1.45	1.00	0.0145
Heptachlor	2	2.90	2.56	0.0743
Malathion	2	2.90	0.50	0.0146
Parathion, ethyl	1	1.45	2.00	0.0290
Ramrod	3	4.35	1.40	0.0609
Vernolate	1	1.45	8.00	0.1159

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TABLE 2 (cont'd). *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Oklahoma, 56 Sites				
Borax	2	3.57	1.25	0.0446
Ceresan M	4	7.14	0.01	0.0007
Ceresan red	3	5.36	0.01	0.0005
2,4-D	2	3.57	0.75	0.0268
Disulfoton	1	1.79	0.50	0.0089
Parathion, ethyl	2	3.57	0.75	0.0268
Parathion, methyl	2	3.57	0.50	0.0179
PCNB	1	1.79	0.01	0.0002
Picloram	1	1.79	1.00	0.0179
Toxaphene	1	1.79	2.00	0.0357
Trifluralin	2	3.57	0.88	0.0313
Pennsylvania, 29 Sites				
Amitrole	1	3.45	2.11	0.0728
Atrazine	4	13.79	2.16	0.2983
Azinphosmethyl	1	3.45	0.25	0.0086
2,4-D	3	10.34	0.10	0.0100
Malathion	2	6.90	1.13	0.0776
Methoxychlor	2	6.90	1.13	0.0776
Parathion, ethyl	1	3.45	0.25	0.0086
Silvex	1	3.45	0.81	0.0279
South Carolina, 9 Sites				
Carbaryl	3	33.33	0.37	0.1222
2,4-D	1	11.11	0.50	0.0556
DDT	1	11.11	2.00	0.2222
Mevinphos	2	22.22	0.10	0.0222
Parathion, ethyl	1	11.11	1.00	0.1111
TDE	1	11.11	3.00	0.3333
Toxaphene	2	22.22	0.80	0.1778
Trifluralin	3	33.33	0.60	0.2000
South Dakota, 106 Sites				
Aldrin	2	1.89	0.25	0.0048
Atrazine	7	6.60	1.00	0.0658
Barban	1	0.94	0.20	0.0019
Bux-ten (bux)	1	0.94	10.00	0.0943
Captan	20	18.87	0.01	0.0020
Ceresan M	2	1.89	0.01	0.0002
2,4-D	26	24.53	0.48	0.1174
Dieldrin	2	1.89	0.01	0.0002
Heptachlor	1	0.94	0.06	0.0006
Lindane	1	0.94	0.01	0.0001
Malathion	15	14.15	0.11	0.0155
Maneb	1	0.94	0.01	0.0001
MCPA	2	1.89	0.17	0.0033
Methoxychlor	2	1.89	0.08	0.0015
Methylmercury dicyandiamide	7	6.60	0.01	0.0007
Thiram	2	1.89	0.01	0.0002
Toxaphene	1	0.94	2.00	0.0189
Tennessee, 23 Sites				
Atrazine	3	13.04	2.00	0.2609
Carbaryl	1	4.35	7.20	0.3130
Ceresan red	2	8.70	0.01	0.0009
Chloroxuron	2	8.70	1.13	0.0978
Cotoran	2	8.70	0.84	0.0730
2,4-D	1	4.35	1.50	0.0652
DAC	1	4.35	5.00	0.2174
Dalapon	1	4.35	4.00	0.1739
2,4-DB	2	8.70	0.19	0.0170
DDT	1	4.35	0.95	0.0413
Disulfoton	1	4.35	0.01	0.0004
EPTC	1	4.35	0.50	0.0217
Linuron	3	13.04	0.51	0.0670
MSMA	1	4.35	0.28	0.0122
Nitralin	1	4.35	0.60	0.0261
NPA	2	8.70	2.43	0.2113
Parathion, methyl	1	4.35	0.47	0.0204
PCNB	1	4.35	0.01	0.0004
Sodium chlorate	1	4.35	4.50	0.1957
Toxaphene	1	4.35	1.90	0.0826
Trifluralin	1	4.35	1.11	0.0483
Virginia and West Virginia, 21 Sites				
Atrazine	3	14.29	1.33	0.1905
Azinphosmethyl	1	4.76	0.50	0.0238
Captan	2	9.52	0.09	0.0086
DDT	1	4.76	0.25	0.0119
Lindane	1	4.76	0.01	0.0005
Malathion	1	4.76	0.01	0.0005
Sutan	1	4.76	3.00	0.1429
Toxaphene	1	4.76	0.50	0.0238

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TABLE 2 (cont'd). *Pesticides applied to cropland by State, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Wisconsin, 67 Sites				
Aldrin	1	1.49	5.00	0.0746
Amiben	2	2.99	11.50	0.3433
Atrazine	17	25.37	2.12	0.5373
Carbaryl	1	1.49	1.25	0.0187
2,4-D	2	2.99	0.57	0.0172
Diazinon	1	1.49	9.00	0.1343
Disulfoton	1	1.49	1.00	0.0149
MCPA	1	1.49	0.25	0.0037
Phorate	1	1.49	7.00	0.1045
Ramrod	1	1.49	1.50	0.0224
Trifluralin	1	1.49	1.50	0.0224

[1] To convert lb/a to kg/ha., multiply by 1.1208.
[2] Use records were available for only 51 of the 150 sites in Illinois
[3] Mid-Atlantic States include Maryland, Delaware, and New Jersey.
[4] New England States include Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

TABLE 3. *Pesticides applied to cropland by crop, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Alfalfa and Bur Clover, 114 Sites				
Azinphosmethyl	2	1.75	0.38	0.0066
Carbaryl	1	0.88	1.00	0.0088
Malathion	2	1.75	1.13	0.0197
Methoxychlor	2	1.75	1.13	0.0197
Parathion, ethyl	3	2.63	0.50	0.0132
Field Corn, 366 Sites				
Aldrin	51	13.93	1.00	0.1398
Amiben	3	0.82	1.47	0.0120
Amitrole	1	0.27	2.11	0.0058
Atrazine	146	39.89	1.75	0.7001
Bux-ten (bux)	16	4.37	2.27	0.0990
Captan	87	23.77	0.02	0.0052
Carbaryl	5	1.37	1.49	0.0204
CDAA	1	0.27	0.60	0.0016
Ceresan red	1	0.27	0.10	0.0003
Chevron RE-5353	1	0.27	0.70	0.0019
2,4-D	72	19.67	0.64	0.1266
Dalapon	2	0.55	2.50	0.0137
2,4-DB	1	0.27	1.00	0.0027
DDT	1	0.27	0.25	0.0007
Diazinon	9	2.46	2.15	0.0528
Dicamba	1	0.27	0.02	0.0001
Dichlorprop	1	0.27	0.50	0.0014
Disulfoton	4	1.09	1.11	0.0121
Fensulfothion	4	1.09	1.20	0.0132
Furadan	1	0.27	1.00	0.0027
Heptachlor	20	5.46	0.79	0.0433
Isopestox	1	0.27	0.01	0.0000
Lasso	3	0.82	0.92	0.0076
Lindane	3	0.82	0.01	0.0001
Linuron	4	1.09	0.90	0.0098
Malathion	71	19.40	0.01	0.0019
Maneb	1	0.27	0.01	0.0000
MCPA	1	0.27	1.00	0.0027
Methoxychlor	18	4.92	0.02	0.0011
MSMA	1	0.27	3.00	0.0082
Nitrate	4	1.09	49.88	0.5451
Parathion, ethyl	1	0.27	0.02	0.0001
Phorate	16	4.37	1.23	0.0539
Ramrod	40	10.93	1.49	0.1628
Silvex	2	0.55	0.45	0.0025
Simazine	1	0.27	2.20	0.0060
Sutan	5	1.37	3.95	0.0540
Thiram	2	0.55	0.01	0.0001
Toxaphene	1	0.27	0.50	0.0014

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TABLE 3 (cont'd). *Pesticides applied to cropland by crop, FY-70*

Pesticide	No. Sites Using Pesticide	Percent Sites Using Pesticide	Arith. Mean Appl. Rate (lb/a)[1]	Arith. Mean (lb/a)[1]
Cotton, 52 Sites				
Azinphosmethyl	1	1.92	3.00	0.0577
Azodrin	6	11.54	4.28	0.4942
Bidrin	8	15.38	0.31	0.0471
Calcium arsenate	1	1.92	9.80	0.1885
Captan	1	1.92	0.01	0.0002
Carbaryl	4	7.69	5.15	0.3962
Ceresan L	1	1.92	0.01	0.0002
Ceresan M	2	3.85	0.05	0.0021
Ceresan red	7	13.46	0.04	0.0048
Chlorobenzilate	1	1.92	1.00	0.0192
Chloroneb	5	9.62	0.01	0.0012
Cotoran	13	25.00	0.64	0.1608
DAC	1	1.92	4.00	0.0769
DDT	24	46.15	4.69	2.1625
DEF	6	11.54	1.44	0.1658
Dicofol	2	3.85	0.88	0.0337
Dimenthoate	1	1.92	0.33	0.0063
Dinitrocresol	2	3.85	0.10	0.0040
Disulfoton	4	7.69	0.01	0.0012
Diuron	8	15.38	0.47	0.0717
DSMA	6	11.54	2.02	0.2331
Endothall	1	1.92	0.90	0.0173
Endrin	3	5.77	4.16	0.2400
EPN	2	3.85	1.10	0.0423
Folex	7	13.46	1.30	0.1750
Linuron	2	3.85	0.79	0.0304
Malathion	1	1.92	2.50	0.0481
Methyl demeton	1	1.92	0.25	0.0048
Methylmercury dicyandiamide	1	1.92	0.01	0.0002
Methyl trithion	2	3.85	7.75	0.2981
Monuron	2	3.85	0.31	0.0121
MSMA	11	21.15	1.48	0.3138
Norea	1	1.92	1.00	0.0192
Nitralin	5	9.62	0.70	0.0669
Paraquat	6	11.54	0.18	0.0210
Parathion, ethyl	2	3.85	0.09	0.0035
Parathion, methyl	31	59.62	4.89	2.9129
PCNB	2	3.85	0.01	0.0004
Phorate	1	1.92	0.50	0.0096
Prometryne	1	1.92	0.75	0.0144
Sodium chlorate	4	7.69	6.88	0.5288
Strobane	1	1.92	3.00	0.0577
TDE	1	1.92	6.00	0.1154
Toxaphene	20	38.46	6.94	2.6696
Trifluralin	23	44.23	1.03	0.4550
Grass/Hay, 30 Sites				
Atrazine	1	3.33	2.50	0.0833
Simazine	1	3.33	2.50	0.0833
Mixed Hay, 119 Sites				
Malathion	1	0.84	1.00	0.0084
Parathion, ethyl	1	0.84	2.00	0.0168
Soybeans, 257 Sites				
Amiben	47	18.29	1.48	0.2710
Azinphosmethyl	1	0.39	4.00	0.0156
Captan	3	1.17	0.03	0.0004
Carbaryl	5	1.95	1.36	0.0265
CDEA	1	0.39	2.00	0.0078
Ceresan red	1	0.39	0.10	0.0004
CIPC	1	0.39	0.66	0.0026
Chloroxuron	3	1.17	1.42	0.0165
Cotoran	1	0.39	0.90	0.0035
DAC	1	0.39	5.00	0.0195
Dalapon	2	0.78	4.50	0.0350
2,4-DB	5	1.95	0.43	0.0083
DDT	3	1.17	16.65	0.1944
Dinitrobutylphenol	3	1.17	4.17	0.0487
Dinitrocyclohexylphenol	1	0.39	0.50	0.0019
EPTC	1	0.39	0.50	0.0019
Lasso	9	3.50	1.10	0.0386
Linuron	9	3.50	0.87	0.0303
Methylmercury dicyandiamide	1	0.39	0.01	0.0000
Nitralin	2	0.78	0.88	0.0068
NPA	6	2.33	2.02	0.0472
Parathion, ethyl	1	0.39	48.00	0.1868
Parathion, methyl	10	3.89	3.05	0.1186
Ramrod	3	1.17	1.33	0.0156
Toxaphene	3	1.17	49.30	0.5755
Trifluralin	22	8.56	0.78	0.0670
Vernolate	2	0.78	4.65	0.0362

[1] To convert lb/a to kg/ha., multiply by 1.1208.

TABLE 4. *Chlorinated hydrocarbon residues in cropland soil, all sites[1]—FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Geom. Mean Conc., ppm	95% Conf. Interval about Geom. Mean, ppm	Range of Detected Residues, ppm
Aldrin	203	13.48	0.02	0.0032	0.0027-0.0038	0.01- 4.25
Chlordane	165	10.96	0.08	0.0044	0.0036-0.0053	0.01- 13.34
DAC	1	0.07	<0.01	—	—	1.19
o,p'-DDE	43	2.86	<0.01	—	—	0.01- 0.51
p,p'-DDE	317	21.05	0.05	0.0062	0.0053-0.0071	0.01- 6.82
o,p'-DDT	211	14.01	0.04	0.0037	0.0031-0.0043	0.01- 11.70
p,p'-DDT	305	20.25	0.18	0.0085	0.0072-0.0098	0.01- 69.30
DDTR	343	22.78	0.30	0.0116	0.0099-0.0134	0.01-113.09
Dieldrin	465	30.88	0.04	0.0097	0.0086-0.0109	0.01- 1.85
Endosulfan (I)	1	0.07	<0.01	—	—	0.01
Endosulfan (II)	4	0.27	<0.01	—	—	0.02- 0.07
Endosulfan sulfate	5	0.33	<0.01	—	—	0.10- 0.29
Endrin	27	1.79	<0.01	—	—	0.01- 0.90
Heptachlor	98	6.51	0.01	—	—	0.01- 1.71
Heptachlor epoxide	147	9.76	0.01	0.0016	0.0013-0.0019	0.01- 0.34
Isodrin	34	2.26	<0.01	—	—	0.01- 0.18
Lindane	6	0.40	<0.01	—	—	0.01- 0.15
Nitralin	1	0.07	<0.01	—	—	2.47
Ramrod	1	0.07	<0.01	—	—	0.03
o,p'-TDE	37	2.46	0.01	—	—	0.01- 4.87
p,p'-TDE	217	14.41	0.03	0.0033	0.0028-0.0038	0.01- 20.40
Toxaphene	27	1.79	0.06	—	—	0.79- 8.75
Trifluralin	33	2.19	<0.01	—	—	0.01- 0.36

NOTE: All residues on dry-weight basis.
[1] 1,506 analyses, 35 States.

TABLE 5. *Chlorinated hydrocarbon residues in cropland soil by State, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Alabama, 21 Sites				
Chlordane	1	4.76	0.01	0.23
DAC	1	4.76	0.06	1.19
o,p'-DDE	2	9.52	<0.01	0.02-0.08
p,p'-DDE	17	80.95	0.13	0.02-0.49
o,p'-DDT	13	61.90	0.09	0.01-0.47
p,p'-DDT	16	76.19	0.50	0.03-3.08
DDTR	17	80.95	0.77	0.05-3.83
Dieldrin	4	19.05	<0.01	0.01-0.03
Endrin	2	9.52	0.01	0.05-0.16
Heptachlor epoxide	1	4.76	<0.01	0.03
Lindane	2	9.52	<0.01	0.01
o,p'-TDE	2	9.52	0.01	0.04-0.08
p,p'-TDE	12	57.14	0.04	0.01-0.20
Trifluralin	6	28.57	0.02	0.02-0.13
Arkansas, 47 Sites				
Aldrin	8	17.02	<0.01	0.01-0.05
o,p'-DDE	3	6.38	<0.01	0.01-0.03
p,p'-DDE	25	53.19	0.13	0.01-1.25
o,p'-DDT	15	31.91	0.06	0.01-0.62
p,p'-DDT	22	46.81	0.47	0.03-3.98
DDTR	25	53.19	0.69	0.02-5.30
Dieldrin	12	25.53	0.03	0.04-0.22
Endrin	3	6.38	<0.01	0.01-0.03
Lindane	1	2.13	<0.01	0.01
Nitralin	1	2.13	0.05	2.47
o,p'-TDE	2	4.26	0.01	0.09-0.21
p,p'-TDE	18	38.30	0.03	0.01-0.31
Trifluralin	2	4.26	0.01	0.01-0.36
California, 65 Sites				
Aldrin	1	1.54	<0.01	0.17
Chlordane	2	3.08	<0.01	0.10-0.20
o,p'-DDE	14	21.54	0.01	0.01-0.38
p,p'-DDE	41	63.08	0.17	0.01-1.39
o,p'-DDT	32	49.23	0.08	0.01-0.62
p,p'-DDT	40	61.54	0.38	0.01-5.16
DDTR	46	70.77	0.74	0.01-7.75
Dieldrin	23	35.38	0.05	0.01-1.28
Endosulfan (I)	1	1.54	<0.01	0.01
Endosulfan (II)	2	3.08	<0.01	0.04-0.06
Endosulfan sulfate	2	3.08	0.01	0.17-0.29
Endrin	5	7.69	<0.01	0.02-0.10
Heptachlor expoxide	2	3.08	<0.01	0.01
o,p'-TDE	12	18.46	0.01	0.01-0.26
p,p'-TDE	34	52.31	0.08	0.01-1.20
Toxaphene	13	20.00	0.61	0.79-7.63

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TABLE 5 (cont'd). *Chlorinated hydrocarbon residues in cropland soil by State, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Florida, 17 Sites				
Aldrin	1	5.88	<0.01	0.06
Chlordane	2	11.76	0.17	0.10- 2.72
p,p'-DDE	7	41.18	0.35	0.01- 5.41
o,p'-DDT	5	29.41	0.25	0.01- 4.18
p,p'-DDT	9	52.94	1.24	0.02-20.26
DDTR	9	52.94	1.97	0.03-31.99
Dieldrin	5	29.41	0.21	0.05- 1.85
Endrin	1	5.88	0.05	0.90
Heptachlor	1	5.88	0.01	0.19
Heptachlor epoxide	1	5.88	0.01	0.09
p,p'-TDE	3	17.65	0.13	0.01- 2.14
Toxaphene	1	5.88	0.34	5.71
Georgia, 28 Sites				
o,p'-DDE	4	14.29	<0.01	0.01-0.02
p,p'-DDE	23	82.14	0.22	0.01-1.09
o,p'-DDT	19	67.86	0.13	0.02-0.84
p,p'-DDT	23	82.14	0.74	0.02-3.38
DDTR	24	85.71	1.21	0.03-5.11
Lindane	1	3.57	<0.01	0.07
o,p'-TDE	2	7.14	<0.01	0.02-0.09
p,p'-TDE	21	75.00	0.11	0.01-0.99
Toxaphene	3	10.71	0.17	1.21-2.27
Trifluralin	2	7.14	<0.01	0.02-0.03
Illinois, 140 Sites				
Aldrin	73	52.14	0.08	0.01-1.38
Chlordane	48	34.29	0.25	0.05-3.76
p,p'-DDE	11	7.86	0.01	0.02-0.16
o,p'-DDT	2	1.43	<0.01	0.01-0.02
p,p'-DDT	13	9.29	0.01	0.02-0.20
DDTR	14	10.00	0.01	0.03-0.33
Dieldrin	96	68.57	0.15	0.02-0.92
Heptachlor	45	32.14	0.03	0.01-0.65
Heptachlor epoxide	46	32.86	0.02	0.01-0.34
Isodrin	20	14.29	<0.01	0.01-0.04
Lindane	1	0.71	<0.01	0.02
p,p'-TDE	5	3.57	<0.01	0.02-0.04
Trifluralin	1	0.71	<0.01	0.03
Indiana, 78 Sites				
Aldrin	15	19.23	0.07	0.01-1.61
Chlordane	6	7.69	0.07	0.09-1.51
Dieldrin	17	21.79	0.04	0.02-0.58
Heptachlor	7	8.97	0.01	0.01-0.21
Heptachlor epoxide	5	6.41	<0.01	0.01-0.12
Isodrin	5	6.41	<0.01	0.01-0.18
Trifluralin	1	1.28	<0.01	0.06
Iowa, 150 Sites				
Aldrin	43	28.67	0.03	0.01-0.68
Chlordane	30	20.00	0.17	0.01-8.04
p,p'-DDE	10	6.67	<0.01	0.01-0.22
o,p'-DDT	6	4.00	<0.01	0.01-0.09
p,p'-DDT	14	9.33	0.01	0.02-0.41
DDTR	14	9.33	0.02	0.03-0.72
Dieldrin	95	63.33	0.07	0.01-0.56
Heptachlor	19	12.67	0.02	0.01-1.71
Heptachlor epoxide	33	22.00	0.01	0.01-0.28
Isodrin	1	0.67	<0.01	0.01
Lindane	1	0.67	<0.01	0.15
Ramrod	1	0.67	<0.01	0.03
p,p'-TDE	8	5.33	<0.01	0.01-0.05
Kentucky, 30 Sites				
Aldrin	1	3.33	<0.01	0.04
o,p'-DDE	1	3.33	<0.01	0.01
p,p'-DDE	8	26.67	0.01	0.01-0.15
o,p'-DDT	3	10.00	0.01	0.02-0.09
p,p'-DDT	6	20.00	0.02	0.02-0.31
DDTR	8	26.67	0.04	0.02-0.59
Dieldrin	8	26.67	0.01	0.01-0.06
o,p'-TDE	1	3.33	<0.01	0.03
p,p'-TDE	6	20.00	0.01	0.01-0.11
Toxaphene	1	3.33	0.03	0.89

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TABLE 5 (cont'd). *Chlorinated hydrocarbon residues in cropland soil by State, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Louisiana, 26 Sites				
Aldrin	1	3.85	<0.01	0.04
o,p'-DDE	2	7.69	<0.01	0.02-0.10
p,p'-DDE	12	46.15	0.20	0.02-1.98
o,p'-DDT	10	38.46	0.07	0.01-0.56
p,p'-DDT	12	46.15	0.40	0.06-3.21
DDTR	12	46.15	0.70	0.09-6.02
Dieldrin	8	30.77	0.02	0.02-0.08
Endrin	2	7.69	<0.01	0.02-0.03
Heptachlor	1	3.85	<0.01	0.01
p,p'-TDE	11	42.31	0.03	0.01-0.17
Toxaphene	1	3.85	0.20	5.32
Trifluralin	2	7.69	0.01	0.07-0.19
Michigan, 54 Sites				
Chlordane	3	5.56	0.01	0.07- 0.51
o,p'-DDE	1	1.85	0.01	0.51
p,p'-DDE	7	12.96	0.06	0.01- 2.38
o,p'-DDT	5	9.26	0.16	0.04- 8.21
p,p'-DDT	6	11.11	0.26	0.03-12.03
DDTR	7	12.96	0.53	0.01-25.59
Dieldrin	7	12.96	0.01	0.01- 0.22
Endosulfan (II)	1	1.85	<0.01	0.02
Endosulfan sulfate	1	1.85	<0.01	0.10
Heptachlor	1	1.85	<0.01	0.04
Heptachlor epoxide	2	3.70	<0.01	0.01
o,p'-TDE	1	1.85	0.02	1.30
p,p'-TDE	5	9.26	0.03	0.02- 1.16
Mid-Atlantic States,[1] 19 Sites				
Aldrin	1	5.26	0.01	0.24
Chlordane	4	21.05	0.72	0.11-13.34
p,p'-DDE	3	15.79	0.02	0.01- 0.22
o,p'-DDT	2	10.53	<0.01	0.02- 0.03
p,p'-DDT	5	26.32	0.03	0.01- 0.38
DDTR	5	26.32	0.10	0.01- 1.46
Dieldrin	9	47.37	0.08	0.01- 0.74
Heptachlor epoxide	1	5.26	<0.01	0.03
p,p'-TDE	3	15.79	0.05	0.02- 0.86
Minnesota, 120 Sites				
Aldrin	6	5.00	0.05	0.03-4.25
Chlordane	8	6.67	0.02	0.03-0.94
o,p'-DDE	1	0.83	<0.01	0.01
p,p'-DDE	12	10.00	0.01	0.01-0.25
o,p'-DDT	9	7.50	<0.01	0.01-0.25
p,p'-DDT	13	10.83	0.02	0.02-0.74
DDTR	13	10.83	0.03	0.02-1.29
Dieldrin	17	14.17	0.02	0.01-0.92
Endrin	2	1.67	<0.01	0.01-0.02
Heptachlor	3	2.50	<0.01	0.01-0.05
Heptachlor epoxide	5	4.17	<0.01	0.01-0.09
Isodrin	2	1.67	<0.01	0.01-0.05
p,p'-TDE	4	3.33	<0.01	0.01-0.08
Mississippi, 29 Sites				
Chlordane	1	3.45	<0.01	0.08
o,p'-DDE	8	27.59	0.01	0.02-0.05
p,p'-DDE	27	93.10	0.28	0.01-1.71
o,p'-DDT	22	75.86	0.19	0.02-0.74
p,p'-DDT	27	93.10	1.29	0.01-6.61
DDTR	27	93.10	1.85	0.03-9.81
Dieldrin	6	20.69	0.02	0.01-0.18
Endrin	3	10.34	0.01	0.02-0.11
Heptachlor epoxide	1	3.45	<0.01	0.03
p,p'-TDE	18	62.07	0.08	0.01-0.71
Toxaphene	5	17.24	0.73	2.79-8.75
Trifluralin	5	17.24	0.03	0.03-0.27
Missouri, 81 Sites				
Aldrin	20	24.69	0.04	0.01-0.49
Chlordane	9	11.11	0.16	0.07-5.62
p,p'-DDE	6	7.41	<0.01	0.01-0.10
o,p'-DDT	2	2.47	<0.01	0.03-0.04
p,p'-DDT	6	7.41	0.01	0.03-0.26
DDTR	6	7.41	0.01	0.04-0.43
Dieldrin	28	34.57	0.06	0.01-0.53
Endrin	1	1.23	<0.01	0.02
Heptachlor	8	9.88	0.03	0.02-0.94
Heptachlor Epoxide	8	9.88	0.01	0.01-0.31
Isodrin	1	1.23	<0.01	0.01
p,p'-TDE	3	3.70	<0.01	0.02-0.04
Trifluralin	5	6.17	<0.01	0.02-0.09

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TABLE 5 (cont'd). *Chlorinated hydrocarbon residues in cropland soil by State, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Nebraska, 106 Sites				
Aldrin	4	3.77	<0.01	0.01
Chlordane	16	15.09	0.01	0.02-0.14
o,p'-DDE	1	0.94	<0.01	0.01
p,p'-DDE	10	9.43	<0.01	0.01-0.19
o,p'-DDT	5	4.72	<0.01	0.01-0.06
p,p'-DDT	7	6.60	0.01	0.03-0.28
DDTR	10	9.43	0.01	0.01-0.59
Dieldrin	48	45.28	0.03	0.01-0.17
Endrin	4	3.77	<0.01	0.01-0.03
Heptachlor epoxide	18	16.98	<0.01	0.01-0.02
p,p'-TDE	3	2.83	<0.01	0.01-0.05
New England States,[a] 20 Sites				
Chlordane	1	5.00	0.01	0.19
o,p'-DDE	1	5.00	<0.01	0.03
p,p'-DDE	5	25.00	0.07	0.01-0.68
o,p'-DDT	5	25.00	0.07	0.01-0.86
p,p'-DDT	5	25.00	0.45	0.02-4.65
DDTR	5	25.00	0.65	0.04-6.65
Dieldrin	2	10.00	0.03	0.32-0.33
Endosulfan (II)	1	5.00	<0.01	0.07
Endosulfan sulfate	1	5.00	0.01	0.23
p,p'-TDE	4	20.00	0.05	0.14-0.43
New York, 38 Sites				
Chlordane	1	2.63	0.01	0.28
p,p'-DDE	13	34.21	0.21	0.01- 6.82
o,p'-DDT	6	15.79	0.31	0.01- 11.70
p,p'-DDT	12	31.58	1.87	0.01- 69.30
DDTR	15	39.47	3.06	0.01-113.09
Dieldrin	10	26.32	0.01	0.01- 0.10
Heptachlor epoxide	1	2.63	<0.01	0.06
o,p'-TDE	1	2.63	0.13	4.87
p,p'-TDE	6	15.79	0.54	0.01- 20.40
North Carolina, 30 Sites				
Aldrin	1	3.33	<0.01	0.02
Chlordane	3	10.00	0.01	0.03-0.32
o,p'-DDE	1	3.33	<0.01	0.02
p,p'-DDE	21	70.00	0.07	0.01-0.44
o,p'-DDT	16	53.33	0.06	0.02-0.43
p,p'-DDT	20	66.67	0.31	0.02-2.93
DDTR	22	73.33	0.53	0.03-4.12
Dieldrin	10	33.33	0.03	0.01-0.29
Endrin	2	6.67	<0.01	0.01-0.03
Heptachlor epoxide	1	3.33	<0.01	0.01
o,p'-TDE	8	26.67	0.01	0.01-0.12
p,p'-TDE	18	60.00	0.07	0.01-0.42
Trifluralin	1	3.33	<0.01	0.07
Ohio, 69 Sites				
Aldrin	17	24.64	0.04	0.01-1.84
Chlordane	15	21.74	0.08	0.05-1.44
p,p'-DDE	6	8.70	<0.01	0.01-0.10
o,p'-DDT	1	1.45	<0.01	0.09
p,p'-DDT	3	4.35	<0.01	0.01-0.28
DDTR	7	10.14	0.02	0.02-0.43
Dieldrin	26	37.68	0.05	0.01-0.77
Endrin	1	1.45	<0.01	0.02
Heptachlor	6	8.70	0.01	0.01-0.27
Heptachlor epoxide	9	13.04	<0.01	0.01-0.05
Isodrin	2	2.90	<0.01	0.01-0.09
o,p'-TDE	4	5.80	<0.01	0.02-0.09
p,p'-TDE	6	8.70	0.01	0.01-0.23
Trifluralin	2	2.90	<0.01	0.04-0.06
Oklahoma, 65 Sites				
p,p'-DDE	12	18.46	0.03	0.01-0.89
o,p'-DDT	7	10.77	0.01	0.02-0.20
p,p'-DDT	9	13.85	0.03	0.02-0.57
DDTR	12	18.46	0.07	0.01-1.71
Dieldrin	1	1.54	<0.01	0.07
Endrin	1	1.54	<0.01	0.06
p,p'-TDE	6	9.23	<0.01	0.01-0.08
Toxaphene	1	1.54	0.02	1.60

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TABLE 5 (cont'd). *Chlorinated hydrocarbon residues in cropland soil by State, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Pennsylvania, 32 Sites				
Chlordane	1	3.13	<0.01	0.02
o,p'-DDE	1	3.13	<0.01	0.01
p,p'-DDE	9	28.13	0.05	0.01-0.74
o,p'-DDT	4	12.50	0.01	0.01-0.08
p,p'-DDT	9	28.13	0.04	0.02-0.42
DDTR	9	28.13	0.09	0.04-1.26
Dieldrin	2	6.25	0.01	0.02-0.25
Heptachlor epoxide	2	6.25	<0.01	0.01
p,p'-TDE	4	12.50	<0.01	0.01-0.05
South Carolina, 17 Sites				
Aldrin	1	5.88	<0.01	0.01
Chlordane	1	5.88	0.05	0.92
o,p'-DDE	2	11.76	<0.01	0.02
p,p'-DDE	13	76.47	0.23	0.04-0.77
o,p'-DDT	12	70.59	0.15	0.01-0.59
p,p'-DDT	13	76.47	0.63	0.05-2.98
DDTR	13	76.47	1.10	0.12-4.04
Dieldrin	3	17.65	0.06	0.01-0.98
Endosulfan sulfate	1	5.88	0.01	0.10
o,p'-TDE	1	5.88	0.01	0.09
p,p'-TDE	11	64.71	0.07	0.02-0.61
Toxaphene	2	11.76	0.34	2.44-3.34
Trifluralin	3	17.65	0.01	0.02-0.11
South Dakota, 106 Sites				
Aldrin	6	5.66	0.01	0.01-0.22
Chlordane	1	0.94	<0.01	0.03
p,p'-DDE	1	0.94	<0.01	0.02
o,p'-DDT	2	1.89	<0.01	0.01-0.02
p,p'-DDT	3	2.83	<0.01	0.03-0.04
DDTR	3	2.83	<0.01	0.05
Dieldrin	12	11.32	0.01	0.01-0.46
Isodrin	1	0.94	<0.01	0.01
Tennessee, 25 Sites				
Chlordane	3	12.00	0.05	0.09-0.77
o,p'-DDE	1	4.00	<0.01	0.02
p,p'-DDE	7	28.00	0.02	0.01-0.31
o,p'-DDT	4	16.00	0.01	0.01-0.14
p,p'-DDT	5	20.00	0.04	0.01-0.65
DDTR	8	32.00	0.08	0.01-1.44
Dieldrin	6	24.00	0.01	0.01-0.06
Heptachlor	2	8.00	<0.01	0.01
Heptachlor epoxide	2	8.00	<0.01	0.01-0.11
o,p'-TDE	1	4.00	<0.01	0.08
p,p'-TDE	4	16.00	0.01	0.02-0.24
Trifluralin	1	4.00	<0.01	0.01
Virginia and West Virginia, 26 Sites				
Chlordane	3	11.54	0.02	0.04-0.37
p,p'-DDE	4	15.38	0.01	0.04-0.08
o,p'-DDT	2	7.69	<0.01	0.01-0.03
p,p'-DDT	3	11.54	0.01	0.01-0.14
DDTR	5	19.23	0.02	0.01-0.23
Dieldrin	3	11.54	<0.01	0.02
Heptachlor epoxide	3	11.54	0.01	0.03-0.13
o,p'-TDE	1	3.85	<0.01	0.01
p,p'-TDE	3	11.54	<0.01	0.01-0.06
Wisconsin, 67 Sites				
Aldrin	4	5.97	0.04	0.02-1.40
Chlordane	6	8.96	0.05	0.06-1.46
p,p'-DDE	7	10.45	0.01	0.01-0.34
o,p'-DDT	2	2.99	0.01	0.13-0.35
p,p'-DDT	4	5.97	0.02	0.02-1.11
DDTR	7	10.45	0.04	0.01-1.91
Dieldrin	7	10.45	0.02	0.01-0.34
Heptachlor	5	7.46	<0.01	0.01-0.03
Heptachlor epoxide	6	8.96	<0.01	0.01-0.06
Isodrin	2	2.99	<0.01	0.02-0.03
o,p'-TDE	1	1.49	<0.01	0.01
p,p'-TDE	1	1.49	<0.01	0.10
Trifluralin	2	2.99	<0.01	0.01-0.05

NOTE: All residues on dry-weight basis.

[1] Mid-Atlantic States include Maryland, Delaware, and New Jersey.

[2] New England States include Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

TABLE 6. *Chlorinated hydrocarbon residues in cropland soil by State, FY-70*
(50% estimate and 95% confidence interval of median)

Pesticide	Upper Limit,[1] ppm	Residue Level, ppm	Lower Limit, ppm
ALABAMA			
p,p'-DDE	0.07	0.06	0.05
o,p'-DDT	0.03	0.02	0.01
p,p'-DDT	0.13	0.11	0.09
DDTR	0.28	0.24	0.20
p,p'-TDE	0.02	0.02	0.01
ARKANSAS			
p,p'-DDE	0.01	0.01	0.01
p,p'-DDT	0.03	0.02	0.01
DDTR	0.04	0.03	0.03
Dieldrin	0.02	0.01	0.01
p,p'-TDE	0.01	0.01	0.00
CALIFORNIA			
p,p'-DDE	0.05	0.04	0.03
o,p'-DDT	0.02	0.02	0.01
p,p'-DDT	0.07	0.06	0.05
DDTR	0.16	0.13	0.11
Dieldrin	0.01	0.00	0.00
p,p'-TDE	0.02	0.02	0.01
Toxaphene	0.34	0.20	0.08
FLORIDA			
p,p'-DDE	0.01	0.00	0.00
p,p'-DDT	0.02	0.01	0.01
DDTR	0.03	0.02	0.01
GEORGIA			
p,p'-DDE	0.11	0.09	0.07
o,p'-DDT	0.05	0.04	0.04
p,p'-DDT	0.37	0.29	0.21
DDTR	0.62	0.46	0.32
p,p'-TDE	0.03	0.03	0.02
ILLINOIS			
Aldrin	0.01	0.01	0.01
Chlordane	0.04	0.03	0.02
p,p'-DDT	0.01	0.00	0.00
Dieldrin	0.07	0.06	0.06
INDIANA			
Chlordane	0.01	0.00	0.00
Dieldrin	0.01	0.00	0.00
IOWA			
Dieldrin	0.02	0.02	0.02
KENTUCKY			
DDTR	0.01	0.00	0.00

Pesticide	Upper Limit,[1] ppm	Residue Level, ppm	Lower Limit, ppm
LOUISIANA			
p,p'-DDE	0.01	0.01	0.00
o,p'-DDT	0.01	0.00	0.00
p,p'-DDT	0.05	0.03	0.01
DDTR	0.08	0.04	0.02
p,p'-TDE	0.01	0.01	0.00
MISSISSIPPI			
p,p'-DDE	0.12	0.10	0.08
o,p'-DDT	0.10	0.08	0.07
p,p'-DDT	0.53	0.37	0.25
DDTR	0.80	0.57	0.38
p,p'-TDE	0.04	0.03	0.01
MISSOURI			
p,p'-DDT	0.01	0.00	0.00
Dieldrin	0.01	0.01	0.00
NEBRASKA			
Chlordane	0.01	0.00	0.00
p,p'-DDT	0.01	0.00	0.00
Dieldrin	0.01	0.01	0.00
NORTH CAROLINA			
p,p'-DDE	0.03	0.02	0.02
o,p'-DDT	0.02	0.01	0.01
p,p'-DDT	0.06	0.05	0.04
DDTR	0.14	0.12	0.09
Dieldrin	0.01	0.00	0.00
o,p'-TDE	0.01	0.00	0.00
p,p'-TDE	0.03	0.02	0.02
OHIO			
Chlordane	0.01	0.00	0.00
PENNSYLVANIA			
p,p'-DDT	0.01	0.00	0.00
DDTR	0.02	0.01	0.01
SOUTH CAROLINA			
p,p'-DDE	0.15	0.11	0.07
o,p'-DDT	0.06	0.04	0.02
p,p'-DDT	0.24	0.17	0.10
DDTR	0.60	0.40	0.20
p,p'-TDE	0.03	0.02	0.02
WISCONSIN			
Chlordane	0.01	0.00	0.00

NOTE: All residues on dry-weight basis.
[1] Values not shown where upper limit is less than 0.01 ppm.

TABLE 7. *Chlorinated hydrocarbon residues in cropland soil by cropping region, FY-70*
(% sites showing detectable residues)

Pesticide	Corn	Cotton	Cotton & Gen. Farming	Gen. Farming	Hay & Gen. Farming	Irrigated Land	Small Grains	Veg.	Veg. & Fruit
	NUMBER OF SITES ANALYZED								
	713	101	117	147	184	39	105	72	42
	PERCENT OF SITES SHOWING DETECTABLE RESIDUES								
Aldrin	25.39	7.92	2.56	2.04	1.09	5.13	0.95	1.39	4.76
Chlordane	18.51	ND	3.42	6.12	4.35	7.69	0.95	6.94	9.52
DAC	ND	ND	0.85	ND	ND	ND	ND	ND	ND
o,p'-DDE	0.14	12.87	5.98	4.08	2.17	28.21	ND	ND	4.76
p,p'-DDE	6.87	58.42	48.72	41.50	15.22	56.41	2.86	27.78	47.62
o,p'-DDT	3.09	41.58	33.33	30.61	7.07	46.15	1.90	20.83	33.33
p,p'-DDT	7.57	55.45	44.44	37.41	12.50	48.72	1.90	30.56	52.38
DDTR	8.42	59.41	48.72	44.22	15.22	58.97	2.86	33.33	59.52
Dieldrin	45.44	23.76	14.53	17.69	9.78	56.41	4.76	23.61	30.95
Endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	2.38
Endosulfan II	ND	ND	ND	ND	1.09	2.56	ND	ND	2.38
Endosulfan sulfate	ND	ND	0.85	ND	1.63	2.56	ND	ND	2.38
Endrin	0.42	5.94	4.27	1.36	ND	10.26	3.81	1.39	4.76
Heptachlor	12.76	ND	0.85	0.68	1.63	2.56	ND	ND	2.38
Heptachlor epoxide	17.11	ND	1.71	4.08	4.35	12.82	0.95	1.39	4.76
Isodrin	4.63	ND	ND	ND	0.54	ND	ND	ND	ND
Lindane	0.28	0.99	1.71	0.68	ND	ND	ND	ND	ND
Nitralin	ND	0.99	ND	ND	ND	ND	ND	ND	ND
Ramrod	0.14	ND	ND	ND	ND	ND	ND	ND	ND
o,p'-TDE	0.56	2.97	1.71	9.52	1.09	25.64	ND	1.39	2.38
p,p'-TDE	3.79	41.58	32.48	36.05	5.98	41.03	0.95	18.06	35.71
Toxaphene	ND	8.91	3.42	3.40	ND	20.51	ND	ND	2.38
Trifluralin	0.70	13.86	5.13	4.08	1.09	ND	ND	ND	ND

NOTE: ND = not detected.

TABLE 8. *Chlorinated hydrocarbon residues in cropland soil by cropping region, FY-70*
(Arithmetic mean conc.)

Pesticide	Corn	Cotton	Cotton & Gen. Farming	Gen. Farming	Hay & Gen. Farming	Irrigated Land	Small Grains	Veg.	Veg. & Fruit
	NUMBER OF SITES ANALYZED								
	713	101	117	147	184	39	105	72	42
	ARITHMETIC MEAN CONC., ppm								
Aldrin	0.05	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01
Chlordane	0.13	ND	0.01	0.02	0.02	0.01	<0.01	0.19	0.07
DAC	ND	ND	0.01	ND	ND	ND	ND	ND	ND
o,p'-DDE	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	ND	ND	0.01
p,p'-DDE	<0.01	0.13	0.15	0.06	0.03	0.16	<0.01	0.13	0.21
o,p'-DDT	<0.01	0.08	0.06	0.05	0.05	0.07	<0.01	0.18	0.13
p,p'-DDT	0.01	0.52	0.35	0.25	0.11	0.31	<0.01	1.06	0.69
DDTR	0.01	0.78	0.59	0.40	0.22	0.64	0.01	1.74	1.11
Dieldrin	0.07	0.04	0.02	0.01	0.01	0.05	<0.01	0.02	0.10
Endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	<0.01
Endosulfan II	ND	ND	ND	ND	<0.01	<0.01	ND	ND	<0.01
Endosulfan sulfate	ND	ND	<0.01	ND	<0.01	<0.01	ND	ND	0.01
Endrin	<0.01	<0.01	<0.01	<0.01	ND	0.01	<0.01	<0.01	0.02
Heptachlor	0.01	ND	<0.01	<0.01	<0.01	<0.01	ND	ND	<0.01
Heptachlor epoxide	0.01	ND	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isodrin	<0.01	ND	ND	ND	<0.01	ND	ND	ND	ND
Lindane	<0.01	<0.01	<0.01	<0.01	ND	ND	ND	ND	ND
Nitralin	ND	0.02	ND	ND	ND	ND	ND	ND	ND
Ramrod	<0.01	ND	ND	ND	ND	ND	ND	ND	ND
o,p'-TDE	<0.01	<0.01	<0.01	0.01	0.01	0.02	ND	0.07	<0.01
p,p'-TDE	<0.01	0.04	0.03	0.04	0.01	0.07	<0.01	0.30	0.08
Toxaphene	ND	0.32	0.09	0.07	ND	0.68	ND	ND	0.14
Trifluralin	<0.01	0.02	<0.01	<0.01	<0.01	ND	ND	ND	ND

NOTE: ND = not detected.

TABLE 9. *Chlorinated hydrocarbon residues in cropland soil by cropping region, FY-70*
(50% estimate and 95% confidence interval for selected pesticides, ppm)

Pesticide	Parameter	Corn	Cotton	Cotton & Gen. Farming	Gen. Farming	Hay & Gen. Farming	Irrigated Land	Veg.	Veg. & Fruit
Chlordane	Upper Limit	0.002	NC	NC	0.001	0.000	NC	NC	NC
	Residue Level	0.001	NC	NC	0.000	0.000	NC	NC	NC
	Lower Limit	0.001	NC	NC	0.000	0.000	NC	NC	NC
p,p'-DDE	Upper Limit	0.000	0.018	0.010	0.009	0.000	0.039	0.002	0.013
	Residue Level	0.000	0.016	0.008	0.007	0.000	0.024	0.001	0.009
	Lower Limit	0.000	0.013	0.006	0.005	0.000	0.011	0.000	0.005
o,p'-DDT	Upper Limit	NC	0.010	0.006	0.005	0.000	0.038	0.000	0.002
	Residue Level	NC	0.008	0.003	0.004	0.000	0.029	0.000	0.002
	Lower Limit	NC	0.005	0.002	0.003	0.000	0.018	0.000	0.001
p,p'-DDT	Upper Limit	0.000	0.054	0.013	0.013	0.000	0.077	0.001	0.019
	Residue Level	0.000	0.046	0.010	0.009	0.000	0.054	0.001	0.015
	Lower Limit	0.000	0.038	0.007	0.006	0.000	0.033	0.000	0.011
DDTR	Upper Limit	0.000	0.085	0.023	0.022	0.000	0.079	0.002	0.047
	Residue Level	0.000	0.071	0.017	0.016	0.000	0.040	0.002	0.037
	Lower Limit	0.000	0.058	0.012	0.011	0.000	0.014	0.001	0.028
Dieldrin	Upper Limit	0.011	0.003	0.002	0.002	0.000	0.027	0.001	0.003
	Residue Level	0.009	0.002	0.001	0.001	0.000	0.018	0.000	0.002
	Lower Limit	0.007	0.001	0.000	0.000	0.000	0.008	0.000	0.001
p,p'-TDE	Upper Limit	0.000	0.009	0.004	0.008	0.000	0.017	0.000	0.006
	Residue Level	0.000	0.008	0.003	0.006	0.000	0.014	0.000	0.005
	Lower Limit	0.000	0.006	0.002	0.005	0.000	0.010	0.000	0.003
Toxaphene	Upper Limit	NC	0.149	NC	NC	NC	0.336	NC	NC
	Residue Level	NC	0.036	NC	NC	NC	0.171	NC	NC
	Lower Limit	NC	0.001	NC	NC	NC	0.041	NC	NC

NOTE: NC = not calculated, less than 6 different values.
All residues on dry-weight basis.

TABLE 10. *Chlorinated hydrocarbon residues in cropland soil by crop, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Alfalfa and Bur Clover, 114 Sites				
Aldrin	8	7.02	0.01	0.01-0.38
Chlordane	10	8.77	0.04	0.03-1.46
o,p'-DDE	4	3.51	<0.01	0.01-0.03
p,p'-DDE	13	11.40	0.02	0.01-0.74
o,p'-DDT	10	8.77	0.01	0.02-0.14
p,p'-DDT	17	14.91	0.02	0.01-0.42
DDTR	17	14.91	0.06	0.02-1.26
Dieldrin	28	24.56	0.03	0.01-0.51
Endrin	3	2.63	<0.01	0.03-0.07
Heptachlor	4	3.51	<0.01	0.01-0.12
Heptachlor epoxide	9	7.89	<0.01	0.01-0.07
o,p'-TDE	4	3.51	<0.01	0.01-0.08
p,p'-TDE	12	10.53	<0.01	0.01-0.10
Toxaphene	4	3.51	0.08	0.79-4.35
Trifluralin	1	0.88	<0.01	0.02
Field Corn, 363 Sites				
Aldrin	75	20.66	0.06	0.01-4.25
Chlordane	64	17.63	0.15	0.02-8.04
o,p'-DDE	3	0.83	<0.01	0.01-0.02
p,p'-DDE	66	18.18	0.02	0.01-1.09
o,p'-DDT	34	9.37	0.01	0.01-0.84
p,p'-DDT	63	17.36	0.04	0.01-2.98
DDTR	73	20.11	0.07	0.01-4.94
Dieldrin	152	41.87	0.06	0.01-0.92
Endrin	4	1.10	<0.01	0.01-0.03
Heptachlor	40	11.02	0.02	0.01-1.71
Heptachlor epoxide	62	17.08	0.01	0.01-0.31
Isodrin	11	3.03	<0.01	0.01-0.18
Lindane	2	0.55	<0.01	0.07-0.15
Ramrod	1	0.28	<0.01	0.03
o,p'-TDE	6	1.65	<0.01	0.02-0.09
p,p'-TDE	40	11.02	0.01	0.01-0.99
Toxaphene	1	0.28	0.01	2.27
Trifluralin	2	0.55	<0.01	0.04-0.10

(Continued next page)

TABLE 10 (cont'd). *Chlorinated hydrocarbon residues in cropland soil by crop, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Cotton, 49 Sites				
Chlordane	1	2.04	<0.01	0.23
DAC	1	2.04	0.02	1.19
o,p'-DDE	15	30.61	0.01	0.02-0.10
p,p'-DDE	40	81.63	0.38	0.01-1.98
o,p'-DDT	37	75.51	0.22	0.01-0.74
p,p'-DDT	38	77.55	1.37	0.04-6.61
DDTR	40	81.63	2.07	0.01-9.81
Dieldrin	9	18.37	0.02	0.01-0.18
Endrin	7	14.29	0.01	0.01-0.16
Heptachlor epoxide	1	2.04	<0.01	0.03
Lindane	2	4.08	<0.01	0.01
Nitralin	1	2.04	0.05	2.47
o,p'-TDE	7	14.29	0.01	0.02-0.12
p,p'-TDE	32	65.31	0.08	0.01-0.71
Toxaphene	7	14.29	0.55	1.04-7.63
Trifluralin	11	22.45	0.02	0.02-0.24
Grass and Hay, 29 Sites				
Aldrin	1	3.45	<0.01	0.04
Chlordane	1	3.45	0.01	0.27
p,p'-DDE	6	20.69	0.01	0.01-0.21
o,p'-DDT	2	6.90	0.01	0.07-0.09
p,p'-DDT	4	13.79	0.02	0.01-0.31
DDTR	6	20.69	0.04	0.02-0.59
Dieldrin	4	13.79	<0.01	0.01-0.06
Heptachlor	1	3.45	<0.01	0.05
Heptachlor epoxide	1	3.45	<0.01	0.09
p,p'-TDE	4	13.79	<0.01	0.01-0.04
Toxaphene	1	3.45	0.03	0.89
Mixed Hay, 118 Sites				
Aldrin	4	3.39	<0.01	0.01-0.04
Chlordane	7	5.93	0.02	0.02-1.23
o,p'-DDE	2	1.69	<0.01	0.01-0.02
p,p'-DDE	13	11.02	0.01	0.01-0.34
o,p'-DDT	7	5.93	<0.01	0.01-0.25
p,p'-DDT	11	9.32	0.02	0.01-1.35
DDTR	14	11.86	0.04	0.01-2.08
Dieldrin	16	13.56	0.01	0.01-0.37
Heptachlor	2	1.69	<0.01	0.09-0.44
Heptachlor epoxide	5	4.24	<0.01	0.01-0.16
o,p'-TDE	3	2.54	<0.01	0.01-0.08
p,p'-TDE	6	5.08	0.01	0.02-0.24
Soybeans, 254 Sites				
Aldrin	37	14.57	0.01	0.01-1.22
Chlordane	19	7.48	0.04	0.01-1.44
o,p'-DDE	7	2.76	<0.01	0.01-0.03
p,p'-DDE	58	22.83	0.03	0.01-1.25
o,p'-DDT	37	14.57	0.02	0.01-0.51
p,p'-DDT	56	22.05	0.11	0.01-3.43
DDTR	59	23.23	0.17	0.01-3.83
Dieldrin	79	31.10	0.03	0.01-0.56
Endrin	2	0.79	<0.01	0.01-0.03
Heptachlor	14	5.51	<0.01	0.01-0.27
Heptachlor epoxide	17	6.69	<0.01	0.01-0.10
Isodrin	2	0.79	<0.01	0.01
Lindane	1	0.39	<0.01	0.02
Nitralin	1	0.39	0.01	2.47
o,p'-TDE	4	1.57	<0.01	0.02-0.21
p,p'-TDE	40	15.75	0.01	0.01-0.31
Toxaphene	3	1.18	0.07	2.79-8.75
Trifluralin	15	5.91	0.01	0.01-0.36

NOTE: All residues on dry-weight basis.

TABLE 11. *Chlorinated hydrocarbon and organophosphate residues in crops, all sites, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Alfalfa and/or Bur Clover				
Chlorinated Hydrocarbons, 39 Sites				
Chlordane	3	7.69	0.01	0.03-0.19
p,p'-DDE	3	7.69	<0.01	0.01-0.02
o,p'-DDT	5	12.82	<0.01	0.01-0.08
p,p'-DDT	11	28.21	0.01	0.01-0.18
DDTR	11	28.21	0.02	0.01-0.34
Dieldrin	3	7.69	<0.01	0.01-0.02
p,p'-TDE	3	7.69	<0.01	0.01-0.14
Organophosphates, 37 Sites: 0 Detections				
Field Corn: Kernels				
Chlorinated Hydrocarbons, 276 Sites				
Dieldrin	1	0.36	<0.01	0.01
Endrin	1	0.36	<0.01	0.03
Organophosphates, 240 Sites				
Ethion	1	0.42	<0.01	0.13
Cotton: Stalks and Green Bolls				
Chlorinated Hydrocarbons, 33 Sites				
o,p'-DDE	3	9.09	<0.01	0.02- 0.04
p,p'-DDE	29	87.88	0.31	0.01- 4.37
o,p'-DDT	29	87.88	0.37	0.01- 2.36
p,p'-DDT	29	87.88	2.95	0.03-27.03
DDTR	30	90.91	3.81	0.02-34.63
Dieldrin	7	21.21	<0.01	0.01- 0.05
Endrin	1	3.03	<0.01	0.05
p,p'-TDE	25	75.76	0.17	0.01- 0.87
Toxaphene	15	45.45	6.96	0.68-55.80
Organophosphates, 18 Sites				
DEF	7	38.89	1.54	0.04-14.28
Diazinon	1	5.56	<0.01	0.06
Folex	1	5.56	0.09	1.55
Malathion	4	22.22	0.16	0.08- 2.17
Parathion, ethyl	3	16.67	0.01	0.02- 0.07
Parathion, methyl	9	50.00	0.58	0.13- 6.20
Grass Hay				
Chlorinated Hydrocarbons, 48 Sites				
Chlordane	1	2.08	<0.01	0.16
p,p'-DDE	5	10.42	<0.01	0.01-0.07
o,p'-DDT	3	6.25	0.01	0.05-0.19
p,p'-DDT	5	10.42	0.06	0.02-2.31
DDTR	5	10.42	0.07	0.03-2.60
Dieldrin	1	2.08	<0.01	0.02
p,p'-TDE	1	2.08	<0.01	0.03
Toxaphene	1	2.08	<0.01	0.05
Organophosphates, 47 Sites				
DEF	1	2.13	<0.01	0.01
Disulfoton	3	6.38	<0.01	0.01
Malathion	1	2.13	<0.01	0.03
Parathion, ethyl	1	2.13	<0.01	0.01
Field Corn: Stalks				
Chlorinated Hydrocarbons, 270 Sites				
Chlordane	14	5.19	0.01	0.01-0.52
o,p'-DDE	2	0.74	<0.01	0.01
p,p'-DDE	33	12.22	<0.01	0.01-0.36
o,p'-DDT	33	12.22	0.01	0.01-0.28
p,p'-DDT	53	19.63	0.03	0.01-2.20
DDTR	54	20.00	0.04	0.01-2.88
Dieldrin	42	15.56	<0.01	0.01-0.09
Heptachlor	1	0.37	<0.01	0.06
Heptachlor epoxide	5	1.85	<0.01	0.01-0.12
p,p'-TDE	29	10.74	<0.01	0.01-0.30
Toxaphene	12	4.44	0.02	0.09-1.35
Organophosphates, 228 Sites				
Malathion	1	0.44	<0.01	0.04

(Continued next page)

TABLE 11 (cont'd). *Chlorinated hydrocarbon and organophosphate residues in crops, all sites, FY-70*

Pesticide	No. Times Pesticide Detected	Percent Occurrence	Arith. Mean Conc., ppm	Range of Detected Residues, ppm
Cotton: Seeds				
Chlorinated Hydrocarbons, 39 Sites				
p,p'-DDE	13	33.33	2.57	0.01-100.01
o,p'-DDT	14	35.90	0.01	0.01- 0.18
p,p'-DDT	20	51.28	0.07	0.01- 1.02
DDTR	20	51.28	2.65	0.01-100.05
Dieldrin	2	5.13	<0.01	0.01
p,p'-TDE	8	20.51	<0.01	0.01- 0.02
Toxaphene	12	30.77	0.15	0.05- 1.85
Organophosphates, 37 Sites				
DEF	17	45.95	0.11	0.02-1.10
Parathion, ethyl	3	8.11	<0.01	0.01-0.03
Parathion, methyl	7	18.92	0.01	0.01-0.08
Mixed Hay				
Chlorinated Hydrocarbons, 29 Sites				
Aldrin	1	3.45	<0.01	0.07
Chlordane	5	17.24	0.07	0.05-1.19
p,p'-DDE	11	37.93	0.01	0.01-0.19
o,p'-DDT	11	37.93	0.01	0.01-0.04
p,p'-DDT	20	68.97	0.02	0.01-0.13
DDTR	20	68.97	0.04	0.01-0.36
Dieldrin	19	65.52	0.01	0.01-0.11
Endrin	1	3.45	<0.01	0.12
Heptachlor	1	3.45	<0.01	0.02
p,p'-TDE	6	20.69	<0.01	0.01-0.02
Toxaphene	4	13.79	0.01	0.05-0.13
Organophosphates, 29 Sites: 0 Detections				
Soybeans: Beans				
Chlorinated Hydrocarbons, 178 Sites				
Chlordane	3	1.69	<0.01	0.01-0.10
Dieldrin	69	38.76	0.01	0.01-0.09
Endrin	15	8.43	<0.01	0.01-0.14
Heptachlor	2	1.12	<0.01	0.01
Heptachlor epoxide	12	6.74	<0.01	0.01-0.05
Ramrod	1	0.56	<0.01	0.24
Toxaphene	19	10.67	0.02	0.08-0.41
Trifluralin	8	4.49	<0.01	0.01-0.09
Organophosphates, 137 Sites: 0 Detections				

NOTE: Samples were examined for organophosphates only when use records indicated they had been applied.
All residues on dry-weight basis.

DDT Moratorium in Arizona—Agricultural Residues after 4 Years[1]

G. W. Ware, B. J. Estesen, and W. P. Cahill

ABSTRACT

The moratorium on agricultural use of DDT in Arizona that began in January 1969 has proved very effective during the 4 years of its enforcement. Residues on green alfalfa have declined significantly during this period to a probable inherent level of 0.03 ppm, wet weight. Soil residues of DDTR have changed almost imperceptibly: this suggests a soil half-life greater than 20 years. These soil residues are mostly DDE; the little remaining DDT is being converted gradually to DDE, the slowly degraded metabolite of DDT.

This paper retracts a statement made in an earlier study which implied violation of the DDT moratorium in the Yuma mesa and valley in Yuma County. Authors have concluded that the consistently high residues in the Yuma area resulted from climatological conditions not found in other sampling areas, rather than from any violation of the moratorium.

Introduction

The current moratorium on agricultural use of DDT in Arizona that began in January 1969 has completed its fourth year *(1,2)*. This is the third report on the status of DDT residues and DDTR, related degradation products, following 18 years of unrestricted use and 4 years of restricted use in Arizona under the guidance of the Arizona Board of Pesticide Control.

Analytical Methods

Soil and alfalfa samples were collected precisely as described in previous reports *(1,2)* from the three major irrigated areas in Arizona: Salt River Valley, which surrounds Phoenix; Pinal County; and the Yuma mesa and valley in Yuma County. Desert soil samples adjacent to these areas were also collected but only from the top 0.25 inch. Authors had hoped to demonstrate that airborne contaminated dust was a prime source of forage contamination. This theory was disproved. Additionally, an earlier study *(3)* was continued to provide reference standards and residue continuity retrospectively through 1967 (Table 1). The sampling sites are located on a 60-mile Maricopa County east-west transect along Baseline Road.

Alfalfa and soil samples were carried through the extraction and cleanup procedures formerly delineated by the authors *(1-3)*.

Analysis was performed by electron-capture/gas-liquid chromatography (EC/GLC). Recovery standards and analytical reagent blanks were carried through the extraction and cleanup procedures for each day's analysis. Recoveries were consistently above 90 percent; however, corrections were not applied to the data presented. The minimum sensitivity of the method was arbitrarily set at 0.02 ng for *p,p'*- and *o,p'*-DDT, DDE, and DDD. Standard curves extended from 0.03 to 0.10 ng. The relative sensitivities were 0.001 ppm for alfalfa and 0.003 ppm for soil. Results are based on a minimum sample size and 6 µl extract injected into the chromatograph.

Analytical EC/GLC confirmatory tests were conducted on a random basis using a double-length GLC column at a temperature slightly higher than that used in previous studies, as well as p-value determinations using acetonitrile and hexane *(4)*. Because of low levels of DDTR and interfering peaks of toxaphene which drifted from nearby cottonfields, all alfalfa extracts were dehydrohalogenated after cleanup on florisil and measured only as *o,p'*- and *p,p'*-DDE as described by Cahill et al. *(5)*.

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[1] Contribution to Regional Project W-45, "Residues of Pesticides and Related Chemicals in the Agricultural Environment—Their Nature, Distribution, Persistence, and Toxicological Implications." University of Arizona Agricultural Experiment Station Journal Series No. 2139. Department of Entomology, University of Arizona, Tucson, Ariz. 85721.

TABLE 1. *DDTR residues (ppm) in green alfalfa, 1967-72, Maricopa County, Ariz.*

Sample	1967 Aug.	1968 Sept.	1969 Sept.	1970 Sept.	1971 Sept.	1972 Sept.
2	—	0.220	0.038	0.050	0.020	0.023*
3	0.283	—	0.027	0.030	—	0.025*
4	0.170	0.120	0.038	0.037	0.031	0.022
5	—	0.060	0.020	0.024	0.011	0.029*
6	0.277	—	0.035	0.022	—	0.008*
8	0.794	—	—	0.027	0.038	0.013*
9	—	0.076	0.034	0.042	0.020	0.029*
10	0.350	0.092	0.054	0.162	0.027	0.031
11	0.453	0.580	0.064	0.047	0.085	0.056
12	0.299	0.077	0.025	0.038	—	0.023*
13	0.606	—	—	0.021	0.027	—
Means[1]	0.404[c]	0.175[b]	0.037[a]	0.045[a]	0.032[a]	0.026[a]

NOTE: — = no samples analyzed; * = substitute adjacent fields.
[1] Means with same letter are not significantly different at the 0.05 level.

TABLE 2. *DDTR residues (ppm) in green alfalfa during 1969-71 DDT moratorium, Maricopa County, Ariz.*

Sample	1969 Jan.	1969 Sept.	1970 Sept.	1971 Sept.	1972 Sept.
1	0.087	0.042	0.057	—	—
2	0.303	0.062	0.050	0.025	0.039*
3	0.102	0.078	0.093	0.038	—
4	0.107	0.047	0.076	0.037	0.046*
5	0.049	0.030	0.025	0.007	0.011
6	0.113	0.064	0.060	0.051	0.045*
7	0.082	0.034	0.023	—	0.055
8	0.125	0.056	—	—	—
9	0.085	0.044	0.101	—	—
10	—	—	0.080	0.059	—
Means[1]	0.117[b]	0.051[a]	0.063[a]	0.036[a]	0.039[a]

NOTE: — = no samples analyzed; * = substitute adjacent fields.
[1] Means with same letter are not significantly different at the 0.05 level.

TABLE 3. *DDTR residues (ppm) in green alfalfa during 1969-71 DDT moratorium, Pinal County, Ariz.*

Sample	1969 Jan.	1969 Sept.	1970 Sept.	1971 Sept.	1972 Sept.
1	0.047	0.042	0.034	0.055	0.041*
2	0.047	0.031	0.059	0.036	—
3	0.142	0.187	—	—	—
4	0.231	0.076	0.071	0.072	0.025
5	0.092	0.130	0.045	—	0.025*
6	0.038	0.058	0.045	—	—
7	0.079	0.118	0.059	0.038	0.044
8	0.068	0.071	0.031	0.034	0.018
9	0.054	0.068	0.057	0.060	—
Means[1]	0.088[b]	0.086[b]	0.050[a]	0.049[a]	0.031[a]

NOTE: — = no samples analyzed; * = substitute adjacent fields.
[1] Means with same letter are not significantly different at the 0.05 level.

TABLE 4. *DDTR residues (ppm) in green alfalfa during 1969-71 DDT moratorium, Yuma County, Ariz.*

Sample	1969 Jan.	1969 Sept.	1970 Sept	1971 Sept.	1972 Jan.	1972 Sept.
1	0.047	0.373	—	0.120	0.025	0.032
2	0.039	0.098	—	—	0.010*	0.017*
3	0.049	0.256	0.084	0.270	0.073*	0.040*
4	0.057	0.093	—	—	0.055*	0.075*
5	0.057	0.545	0.063	0.340	0.047*	0.290*
6	0.044	0.317	—	—	0.035*	0.300*
7	0.059	0.241	—	—	0.026*	0.190*
8	0.036	0.045	0.034	0.031	0.039*	—
9	0.021	0.056	—	—	0.015*	—
10	0.046	0.074	0.051	0.050	0.028	0.045
Means[1]	0.046[a]	0.210[b]	0.058[a]	0.162[b]	0.035[a]	0.123[b]

NOTE: — = no samples analyzed; * = substitute adjacent fields.
[1] Means with same letter are not significantly different at the 0.05 level.

TABLE 5. *DDTR residues (ppm) in soils during 1969-72 moratorium, Maricopa County, Ariz.*

Field No.	1969 Jan.				1970 Sept.				1972 Sept.			
	DDE	*o,p'*-DDT	*p,p'*-DDT	Total[1]	DDE	*o,p'*-DDT	*p,p'*-DDT	Total	DDE	*o,p'*-DDT	*p,p'*-DDT	Total
1	0.35	0.04	0.12	0.54	0.32	0.04	0.11	0.47	0.40	0.04	0.11	0.55
2	0.48	0.17	0.78	1.54	0.79	0.20	0.96	1.95	0.98	0.18	0.47	1.63
3	0.33	0.07	0.16	0.59	1.35	0.13	0.32	1.80	1.24	0.13	0.32	1.69
4	0.49	0.05	0.17	0.74	0.56	0.06	0.22	0.84	0.58	0.05	0.23	0.86
5	0.29	0.05	0.09	0.44	0.15	0.02	0.05	0.22	0.17	0.01	0.05	0.23
6	2.10	0.43	1.10	3.93	2.57	0.39	1.18	4.14	2.58	0.28	0.96	3.82
7	0.84	0.11	0.23	1.22	0.84	0.13	0.23	1.20	0.92	0.09	0.29	1.30
8	2.22	0.38	1.29	4.00	2.50	0.47	1.61	4.58	2.37	0.27	1.21	3.85
9	1.18	0.21	0.91	2.41	1.24	0.24	0.82	2.30	1.12	0.17	0.77	2.06
10	—	—	—	(0.24)	0.48	0.06	0.14	0.68	0.31	0.04	0.07	0.42
Means[2]	0.92	0.17	0.54	1.57[a]	1.08	0.17	0.56	1.82[ab]	1.07	0.13	0.45	1.64[a]
Desert Sample												
1	0.08	<0.01	0.03	0.13	0.48	0.04	0.09	0.61	0.43	0.07	0.09	0.59
2	0.24	0.02	0.06	0.35	0.41	0.05	0.10	0.56	0.28	0.03	0.58	0.89
3	0.44	0.04	0.15	0.67	0.28	0.02	0.07	0.37	0.18	0.02	0.04	0.24
4	—	—	—	(2.39)	1.44	0.09	0.38	1.91	0.54	0.08	0.06	0.68
Means[2]	—	—	—	0.89[a]	0.65	0.05	0.16	0.86[a]	0.36	0.05	0.19	0.60[a]

NOTE: — = no samples analyzed.
[1] Figures in parentheses are missing values calculated by randomized blocks missing value formula.
[2] Means with same letter are not significantly different at the 0.05 level.

TABLE 6. *DDTR residues (ppm) in soils during 1969-72 moratorium, Pinal County, Ariz.*

Field No.	1969 Jan.				1970 Sept.				1972 Sept.			
	DDE	*o,p'*-DDT	*p,p'*-DDT	Total	DDE	*o,p'*-DDT	*p,p'*-DDT	Total[1]	DDE	*o,p'*-DDT	*p,p'*-DDT	Total
1	0.64	0.48	2.43	3.77	0.61	0.35	2.82	3.78	0.74	0.34	2.64	3.72
2	0.27	0.15	1.03	1.52	0.35	0.11	1.00	1.46	0.41	0.13	0.96	1.50
3	1.05	0.32	1.38	2.75	1.32	0.23	1.03	2.58	1.16	0.16	0.80	2.12
4	0.99	0.27	1.04	2.30	1.23	0.24	0.68	2.15	1.40	0.18	0.74	2.32
5	0.16	0.02	0.21	0.41	—	—	—	(0.38)	0.25	0.02	0.16	0.43
6	0.06	0.01	0.07	0.14	—	—	—	(0.06)	0.07	0.01	0.04	0.12
7	1.09	0.28	1.37	2.74	1.41	0.31	1.30	3.02	1.63	0.20	0.80	2.63
8	0.09	<0.01	0.04	0.14	0.06	0.01	0.02	0.09	0.08	0.01	0.02	0.11
9	0.67	0.09	0.29	1.06	0.79	0.08	0.20	1.07	0.74	0.03	0.06	0.83
10	0.66	0.14	0.36	1.16	1.14	0.12	0.27	1.53	1.19	0.15	0.39	1.73
Means[2]	0.57	0.18	0.82	1.60[a]	0.72	0.15	0.76	1.61[a]	0.69	0.12	0.66	1.55[a]
Desert Sample												
1	0.09	<0.01	0.06	0.16	0.18	0.01	0.03	0.22	0.17	0.02	0.12	0.31
2	0.18	0.01	0.11	0.32	0.38	0.03	0.06	0.47	0.21	0.02	0.21	0.44
3	0.05	0.03	0.10	0.21	0.12	0.02	0.05	0.19	0.06	0.01	0.02	0.09
4	0.09	0.03	0.10	0.25	1.18	0.06	0.16	1.40	0.77	0.07	0.09	0.93
Means[2]	0.10	0.02	0.09	0.24[a]	0.47	0.03	0.08	0.57[a]	0.30	0.03	0.11	0.44[a]

NOTE: — = no samples analyzed.
[1] Figures in parentheses are missing values calculated by randomized blocks missing value formula.
[2] Means with same letter are not significantly different at the 0.05 level.

TABLE 7. *DDTR residues (ppm) in soils during 1969-72 moratorium, Yuma County, Ariz.*

Field No.	1969 Jan.				1970 Sept.				1972 Sept.			
	DDE	*o,p'*-DDT	*p,p'*-DDT	Total	DDE	*o,p'*-DDT	*p,p'*-DDT	Total	DDE	*o,p'*-DDT	*p,p'*-DDT	Total
1	0.10	<0.01	0.07	0.17	0.11	0.02	0.06	0.19	0.12	0.02	0.03	0.17
2	0.24	0.05	0.25	0.54	0.35	0.10	0.25	0.70	0.20	0.03	0.07	0.30
3	0.72	0.16	0.72	1.60	0.66	0.18	0.52	1.36	0.79	0.16	0.49	1.44
4	0.59	0.11	0.47	1.17	0.78	0.17	0.49	1.44	0.98	0.15	0.46	1.59
5	0.48	0.05	0.30	0.83	0.44	0.12	0.31	0.87	0.75	0.12	0.34	1.21
6	0.29	0.16	0.74	1.19	0.40	0.14	0.56	1.10	0.48	0.10	0.43	1.01
7	1.29	0.07	0.37	1.73	1.09	0.11	0.35	1.55	1.11	0.09	0.60	1.80
8	0.06	0.01	0.01	0.08	0.00	0.00	0.00	0.04	0.05	<0.01	<0.01	0.07
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	<0.01	<0.01	0.03
10	0.26	0.02	0.03	0.31	0.22	0.02	0.03	0.27	0.17	0.01	0.02	0.20
Means[1]	0.40	0.06	0.30	0.76[a]	0.41	0.09	0.26	0.75[a]	0.47	0.07	0.25	0.78[a]
Desert Sample												
1	0.27	0.02	0.07	0.36	0.22	0.03	0.09	0.34	0.24	0.06	0.09	0.39
2	0.03	0.01	0.02	0.06	0.08	0.01	0.04	0.13	0.02	0.01	0.02	0.05
3	0.02	0.01	0.03	0.06	0.02	0.00	0.03	0.05	0.02	0.01	0.02	0.05
4	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.79	0.07	0.15	1.04
Means[1]	0.08	0.01	0.03	0.12[a]	0.08	0.01	0.04	0.14[a]	0.27	0.04	0.08	0.38[b]

[1] Means with same letter are not significantly different at the 0.05 level.

Results and Discussion

Residues observed in alfalfa and soil samplings during the past 4 years are presented in Tables 1-7 as DDTR. The Student-Newman Keul's test was used to analyze differences among residue means for the various sampling dates. Comparisons were made on least-squares means in the soil samples (Tables 5-7) due to inadequate samples. Residues on alfalfa from all four areas shown in Tables 1-4 appear to have leveled off at about 0.03 ppm except in Yuma County (Table 4), where September residues from 1969 through 1972 were about threefold higher than were September residues from other areas. Sampling in January 1972 indicated that residues in Yuma had declined to the levels of the other areas. High September values for Yuma have occurred consistently in 1969, 1970, and 1971. This condition requires the retraction of a statement in the last report *(2)* indicating violations of the DDT moratorium in the Yuma area. These phenomenally high residues are apparently the result of climatological conditions not found in the other sampling areas.

Residue levels in alfalfa soils did not appear to decline from the last sampling period, September 1970 (Tables 5-7). Because any decline has been imperceptible, the

time required for these residues to reach one-half their present level is now estimated to be greater than 20 years, with desert soils changing the least.

DDTR residues now found in Arizona alfalfa and soil are primarily DDE. DDT residues are slowly becoming DDE and then declining negligibly. As suggested from past studies, future problems arising from DDT will be attributable to DDE, the very slowly degrated metabolite of DDT.

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RESIDUES IN FISH, WILDLIFE, AND ESTUARIES

Mercury Residues in the Common Pigeon (Columba livia) *from the Jackson, Mississippi, Area—1972*

Luther A. Knight, Jr.,[1] and Edward J. Harvey, Sr.[2]

ABSTRACT

Total mercury in the common pigeon (Columba livia) *from the Jackson, Miss., area was measured by atomic absorption spectrophotometry. Pigeons captured in 1972 from downtown Jackson were killed on the day of capture to determine mercury levels in wild birds in urban environments; others were caged and analyzed for mercury residues weekly or biweekly for 9 weeks. Data are presented to show possible pathways by which organisms eliminate this element. Median concentration of mercury in brains of newly captured pigeons was 22 ppb. Claws showed 14 to 85 ppb mercury. Possible sources of mercury contamination in these birds are treated grains, contaminated weed seeds, and naturally occurring mercurials.*

Introduction

Even at trace levels, certain contaminants may have effects on the ecosystem as great or greater than those of the more common pollutants *(1)*. Mercurials have been used for many years in agriculture, industry, and medicine, and have caused much concern about their effects on the biosphere. In his review of mercury uses in Canada, Fimreite emphasized that mercury contamination has been investigated in Scandinavian countries where it has produced greater wildlife problems than have DDT and other organochlorine pesticides used prevalently in Scandinavia *(2)*. The seriousness of water pollution by mercury in industrial effluents was accentuated by the occurrence of Minamata disease in Japan *(3)* and, as a consequence of the potential human health hazard, considerable emphasis has been placed upon the danger of mercurials in the aquatic environment in the United States and Canada. After reviewing sources and uses of mercury, Summer, Saha, and Lee stated that elevated levels of the element may be expected in fish from waters receiving mercury containing industrial and/or municipal wastes *(4)*.

In particular, fish have been used to study the extent and effects of this type of pollution. A number of States have banned the sale of commercial fish or warned against public consumption of fish from contaminated waters *(5)*. Fimreite, Fyfe, and Keith *(6)* demonstrated widespread contamination among seed-eating birds in areas of Canada where mercury-containing fungicides are used in seed treatment. A decline in seed-eating bird populations was traced to the use of mercurials as fungicides in Sweden *(7)*. Findings of elevated levels of mercury in various game birds have prompted several States and the Canadian provinces of Alberta and Saskatchewan to monitor mercurial concentrations in their wildlife *(2,6,8,9)*.

In Mississippi, Knight and Herring reported concentrations of total mercury from less than 0.05 to 0.74 ppm in muscles of largemouth bass from Ross Barnett Reservoir *(10)*. However, there is a lack of data on the extent of trace metal contamination in ecosystems of Mississippi. Organisms which accumulate trace metals can act as indicators of pollution levels in their environments. In view of the paucity of local data on trace elements, a study was initiated to evaluate possible indicator organisms and to measure mercury and lead in the Jackson, Miss., area. This paper reports the preliminary results of monitoring total mercury in the common pigeon *(Columba livia)*.

Analytical Methods

Wild pigeons were chosen as test animals because of their abundance and adaptation to urban environments. Approximately 100 pigeons were captured in an abandoned hotel in downtown Jackson on October 10, 1972. Researchers killed 25 of the birds that day and placed the remainder in outside, off-the-ground cages

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for analysis on a weekly schedule. Birds were fed a commercial pigeon scratch and corn which contained no detectable amounts of mercury residues. This control diet assured authors that any mercury detected in pigeons during the 9 weeks of analyses originated from their urban eating patterns before capture rather than from their control diets.

The flameless atomic absorption method described by Hatch and Ott *(11)* was used to measure total mercury in all birds: those killed at time of capture and those killed during the next 9 weeks. A 1- to 3-g sample of tissue was digested with concentrated nitric and sulfuric acids in a 125-ml flask at 50°C to destroy the organic matter. After dissolution, samples were cooled to room temperature and 6 percent potassium permanganate was added until a faint color persisted. To eliminate excess oxidants, 30 ml of reductant containing hydroxylamine sulfate was added; stannous sulfate was used to reduce mercury compounds to the elemental state. The flask was then placed in the absorption system and removed after maximum absorption was reached. Mercury vapor was vented to the hood. Standards obtained from Beckman Instruments, Inc., Fullerton, Calif., were run in the same manner. Foaming of samples was abated with Dow Corning Antifoam A. For these analyses, a Beckman atomic absorption spectrophotometer system equipped with a 10-inch potentiometric recorder was used.

Recovery rates were determined by adding mercury as HgCl to the various tissues. Data are corrected for recovery rates. The minimum detectable amount of mercury was 5 ppb. Accuracy has been given as 0.1 ppb *(11)* and 0.01 ng *(8)*.

Results and Discussion

No heart tissue sample contained more than 5 ppb total mercury. The median mercury concentration in blood of birds killed on the day of capture was 7 ppb. Brain tissues of these first pigeons had a median residue level of 22 ppb; those caged for 1 week had only 6 ppb mercury in their brains. Subsequent samples of these tissues revealed no more than 5 ppb mercury (Table 1). Tejning determined that domestic fowls fed methylmercury-dicyandiamide-treated grain excreted about 11 percent of the mercury *(12)*. After cessation of experimental feeding, he observed that this loss gradually decreased and finally stopped altogether. Our data indicate that mercury was removed with feces in quantities of about 11 to 13 ppb for the birds. In captivity, however, residues in excreta decreased to levels less than 5 ppb after 5 weeks.

Feathers used in the study included mature and immature contour and down feathers from the tail region. Pigeons that had been in captivity for 1 week showed somewhat higher concentrations of mercury in the plumage than did those of subsequent analyses (Table 1). Mercury concentrations in feathers appear to show no consistent decline after the first week. Some variation in residue concentrations may be expected in natural populations of pigeons. Although analyses were not extended through a complete molting cycle, large concentrations of total mercury in plumage seem to indicate that feathers are a pathway through which the metal is concentrated and eventually lost through molting. This corroborates Tejning's work on pheasants and domestic fowls which showed that most of the mercury in blood and organs is not excreted, but is transported to the plumage *(12)*. Claws also contained sizable amounts of mercury (14-85 ppb), but no pathways were established with the limited data available although the residue level patterns in similar claws and feathers may suggest some correlation.

Crops of pigeons killed on the day of capture contained corn, soybeans, Johnson grass seeds, and miscellaneous weed seeds. Other pigeons from the test birds' population were observed feeding along the right-of-way of a main-line railroad and in the yards of several grain storage facilities. Their drinking water was, for the most part, obtained from Town Creek, a generally sluggish stream receiving industrial waste and runoff that flows within 200 yards of the hotel. Mercury was undetectable in water samples from the creek. Pigeons drinking here have also been observed eating materials from bottom sediments near the shore of the creek. Crop contents of birds from the initial kill showed from less than 5 ppb to 7 ppb mercury. Authors suggest that possible contamination sources are treated grains, contaminated weed seeds, and naturally occurring mercurials. No apparently hazardous sources of mercury contamination were found to be available to these pigeons.

Acknowledgments

We thank Peter Lane, Jackson State University, for identifying the plant materials in the crops of the pigeons, and Johnny Jackson, Jackson, Miss., for making the pigeons available for study.

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TABLE 1. *Residues of total mercury (ppb wet weight) in tissues and feces of pigeons from Jackson, Miss.—1972*

	Weeks in Captivity								
	0	1	2	3	4	5	6	7	9
Brain									
Range	9-230	5-10	—	—	—	—	—	—	—
Median	22	6	ND	ND	ND	ND	ND	ND	ND
No. birds	9	3	3	3	3	3	3	3	3
Feathers									
Range	8-30	22-70	16-20	20-51	22-40	25-26	<5-26	21-33	14-21
Median	19	49	17	22	27	26	13	30	18
No. birds	10	3	3	3	3	3	3	3	3
Skin									
Range	5-44	20-49	6-16	<5-5	<5-7	5-6	—	<5-13	<5-6
Median	29	35	10	5	6	5	ND	11	ND
No. birds	7	3	3	3	3	3	3	3	2
Scales									
Range	—	14-15	6-10	<5-11	8-18	5-10	—	11-19	<5-58
Median	ND	15	8	5	10	5	ND	11	8
No. birds	9	3	3	3	3	3	3	3	3
Liver									
Range	—	<5-9	—	—	<5-5	5-10	—	—	—
Median	ND	6	ND	ND	ND	5	ND	ND	ND
No. birds	9	3	3	3	3	3	3	3	3
Breast									
Range	<5-51	—	—	<5-5	6-9	—	—	—	—
Median	20	ND	ND	5	9	ND	ND	ND	ND
No. birds	7	3	3	3	3	3	3	3	3
Bones									
Range	<5-6	—	—	—	8-16	10-17	—	—	—
Median	ND	ND	ND	ND	8	15	ND	ND	ND
No. birds	9	3	3	3	3	2	3	3	3
Blood									
Range	5-12	—	—	—	—	—	—	—	—
Median	7	ND	ND	ND	ND	ND	ND	ND	ND
No. birds	10	3	2	2	2	2	1	2	3
Heart									
Range	—	—	—	—	—	—	—	—	—
Median	ND	ND	ND	ND	ND	ND	ND	ND	ND
No. birds	8	3	3	3	3	3	3	3	3
Claws [1]	29	59	34	55	14	51	23	47	85
No . birds	20	3	3	3	3	3	3	3	3
Oil Glands [1]	10	29	NS	39	84	—	50	8	13
No. birds	20	3	NS	3	3	3	3	3	3
Feces [1]	11	13	11	9	7	NS	—	—	—
No. birds	20	3	3	3	3	NS	3	3	3

NOTE: — = concentrations of mercury less than 5 ppb.
ND = not determined.
NS = no sample.
[1] Tissues or feces combined for analysis.

Distribution of PCB and p,p'-*DDE Residues in Atlantic Herring* (Clupea harengus harengus) *and Yellow Perch* (Perca flavescens) *in Eastern Canada—1972* [1]

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ABSTRACT

In two localities of Eastern Canada in 1972, Atlantic herring (Clupea harengus harengus) *and yellow perch* (Perca flavescens) *were analyzed for residues of polychlorinated biphenyls (PCB's),* p,p'*–DDE,* p,p'*–DDD, and* p,p'*–DDT, and for lipid and body weight. From each locality, 24 herring and 25 perch were analyzed: all were males between 2 and 4 years old, and all were analyzed individually. Data were statistically evaluated. In most cases PCB,* p,p'*–DDE, and lipid were better approximated by lognormal distribution; weight was better approximated by normal distribution. All determined parameters were highly variable. One objective of the study was to weigh the possibility of using the two species under observation to detect temporal trends in levels of environmental contamination by PCB's and* p,p'*–DDE. The study concludes, however, that it is probably impossible to detect a significant change of PCB levels in fish of equal age in 2 consecutive years by using samples of this size.*

Introduction

This paper describes levels and distribution of polychlorinated biphenyls (PCB's), *p,p'*-DDE, wet body weight, and lipid in Atlantic herring *(Clupea harengus harengus)* and yellow perch *(Perca flavescens)*. An objective of this study was to evaluate the possibility of using these species to detect temporal trends in levels of environmental contamination by PCB's and *p,p'*-DDE. Species originated in waters of Eastern Canada: Gulf of St. Lawrence, Bay of Fundy, and New Brunswick Rivers.

Forest-based industries, mining, and smelting operations are the typical industrial activities in the Gulf of St. Lawrence area. In the past, DDT was used for forest spraying in New Brunswick, Quebec, and Newfoundland; other pesticides are still used for agricultural purposes on Prince Edward Island. The St. Lawrence River runoff may be a source of chlorinated hydrocarbons. Little industrial or agricultural activity takes place in southern Nova Scotia. Surface circulation in the Gulf of Maine—Bay of Fundy area *(1)* may bring chlorinated hydrocarbons from the south into the area.

Occurrence and movement patterns of four major stocks of Atlantic herring *(2)* are illustrated in Figure 1. Levels of PCB's and chlorinated hydrocarbon pesticides in two weight groups of the Banquereau stock and in one weight group of the Gulf of Maine stock have been reported *(3)*. Pooled samples were analyzed in the earlier study; there was no information available on statistical distribution of the residues with which to compare results of the current study. The concentration of PCB's and chlorinated hydrocarbon pesticides in herring oils obtained by commercial processes from the Gulf of St. Lawrence herring stock between 1967 and 1970 was determined by Addison et al. *(4)*. Yellow perch from New Brunswick, Canada, has not been analyzed previously.

[1] Environment Canada, Biological Station, St. Andrews, New Brunswick, Canada.

Materials and Methods

SAMPLING

Samples of herring were obtained from commercial fisheries. Sex, age, and wet body weight were determined; male fish were frozen (−14°C) until analysis. Herring sample B (Gulf of St. Lawrence stock) was taken May 25, 1972; herring sample T (Nova Scotia stock) was taken August 18, 1972 (Tables 1-7). The former fish are spring spawners and the latter are fall spawners; both samples were taken just before spawning. Herring in these samples were 4 years old.

TABLE 1. *Residues of PCB's in muscle of Atlantic herring and yellow perch—Eastern Canada, 1972*

Sample [1]	Residues, μg/g Wet Weight					
	Mean		Standard deviation		Chi square probability, %	
	N	L	N	L	N	L
Herring B	0.31	0.25	0.18	0.27	2	50
Herring T	0.64	0.44	0.49	0.43	5	2
Perch 2	0.089	0.078	0.031	0.18	50	70
Perch 3	0.13	0.12	0.046	0.22	20	80

NOTE: N = data as such; L = logarithmically transformed data. Mean is antilog form; standard deviation is in log form.
[1] Herring samples represented 24 individual fish; perch represented 25.

TABLE 2. *Residues of p,p'-DDE in muscle of Atlantic herring and yellow perch—Eastern Canada, 1972*

Sample [1,2]	Residues, μg/g Wet Weight					
	Mean		Standard deviation		Chi square probability, %	
	N	L	N	L	N	L
Herring B	0.070	0.059	0.048	0.29	10	20
Herring T	0.11	0.085	0.071	0.43	2	70
Perch 3	0.11	0.089	0.040	0.22	1	70

NOTE: N = data as such; L = logarithmically transformed data. Mean is antilog form; standard deviation is in log form.
[1] Herring samples represented 24 individual fish; perch represented 25.
[2] DDE not detectable in perch sample 2.

TABLE 3. *Residues of p,p'-DDD and p,p'-DDT in muscle of Atlantic herring—Eastern Canada, 1972*

Sample [2]	Residues, μg/g Wet Weight [1]			
	Mean		Standard deviation	
	p,p'-DDD	*p,p'*-DDT	*p,p'*-DDD	*p,p'*-DDT
Herring B	0.042	0.021	0.31	0.27
Herring T	0.049	0.041	0.37	0.44

[1] Logarithmically transformed data. Mean is in antilog; standard deviation is in log form.
[2] Herring samples represented 24 individual fish; perch represented 25.

TABLE 4. *Hexane-extractable lipid in muscle of Atlantic herring and yellow perch—Eastern Canada, 1972*

Sample [1]	Lipid, % Wet Weight					
	Mean		Standard deviation		Chi square probability, %	
	N	L	N	L	N	L
Herring B	2.70	1.98	1.93	0.42	2	30
Herring T	12.7	11.7	6.26	0.38	50	5
Perch 2	0.32	0.29	0.17	0.21	20	30
Perch 3	0.54	0.51	0.20	0.17	1	20

NOTE: N = data as such; L = logarithmically transformed data. Mean is in antilog form; standard deviation is in log form.
[1] Herring samples represented 24 individual fish; perch represented 25.

TABLE 5. *Body weight of Atlantic herring and yellow perch—Eastern Canada, 1972*

Sample [1]	Arithmetic mean [2]	Standard deviation	Chi square probability, %
Herring B	188	15	50
Herring T [3]	194	0.066	30
Perch 2	9.3	2.34	80

NOTE: Weights not available for perch sample 3.
[1] Herring samples represented 24 individual fish; perch represented 25.
[2] Grams, wet weight.
[3] Logarithmically transformed data. Mean is in antilog form, standard deviation is in log form.

TABLE 6. *Decrease of PCB and p,p'-DDE residues in muscle of Atlantic herring and yellow perch—Eastern Canada*

Sample [1]	New mean in % of present mean			
	PCB		*p,p'*-DDE	
	Distribution		Distribution	
	N	L	N	L
Herring B	72	76	81	73
Herring T	62	64	73	62
Perch 2	83	82	ND	ND
Perch 3	85	79	82	79

NOTE: N = normal; L = lognormal; ND = no residues detected. Data are statistically significant at 5% probability.
[1] Herring samples represented 24 individual fish; perch represented 25.

Yellow perch were obtained by seining from the shore with a 3-ft-by-15-ft chain-weighted net with floats and a mesh size of ½ inch; Figure 1 indicates sampling stations. Sex, age, and wet body weight were determined and, like the herring, male perch were frozen (− 14°C) until analysis. Perch sample 2 was obtained May 2 and 5, 1972; perch sample 3 was obtained May 25, 1972. Analysis was performed on two- and three-year-old fish from stations 2 and 3, respectively. Station 2 (Grand Falls, St. Croix River) is in a rather sparsely populated area with little agricultural or industrial activity. A pulp mill and two towns with a total population of about 12,000 are located downstream. Station 3 (Grand Point, Grand Lake) is on the St. John River, where pulp mills, potato and food processing plants, and a system of dams are located. The station is about 30 miles downstream from the city of Fredericton (population 25,000), and 40 miles upstream from the city of Saint John (population 100,000).

ANALYSIS

Sample analysis similar to that described in a 1972 study *(5)* utilized the white lateral muscle between the dorsal fin and the lateral line. The sample (5.5-6.0 g for herring, 1.5-2.0 g for perch) was ground with anhydrous sodium sulfate (Fisher Scientific S-421, 30 g) in a mor-

TABLE 7. *Residue levels of PCB's and p,p'-DDE (μg/g wet weight), hexane-extractable lipid (% wet weight), and body weight (g, wet weight), in Atlantic herring and yellow perch—Eastern Canada, 1972*

PCB	p,p'-DDE	Lipid	Weight
Herring B [1]			
0.51	0.18	1.74	202.8
0.21	0.04	2.15	191.3
0.18	0.04	1.53	183.2
0.44	0.10	4.75	180.2
0.15•	0.04•	0.34•	171.7
0.13•	0.04•	0.32•	
0.22	0.06	2.65	182.1
0.17	0.04	0.81	191.0
0.11	0.03	0.42	177.1
0.28	0.06	5.24	196.8
0.16•	0.05•	0.96•	177.1
0.15•	0.04•	0.95•	
0.24	0.06	3.27	178.9
0.51	0.06	1.46	198.4
0.55	0.14	4.76	178.7
0.70	0.19	3.52	192.5
0.10•	0.02•	0.88•	189.1
0.12•	0.03•	1.02•	
0.40	0.09	1.64	192.5
0.26	0.06	4.30	200.3
0.41	0.07	12.94	146.4
0.10	0.03	0.43	164.5
0.12•	0.03•	1.32•	196.7
0.12•	0.03•	1.64•	
0.56	0.16	5.68	210.8
0.42	0.11	4.88	215.1
0.46	0.15	4.91	186.2
0.09•	0.03•	0.48•	208.3
0.12•	0.02•	0.64•	
Herring T [1]			
0.08	0.02	6.28	131.5
0.19	0.03	6.71	145.0
0.20	0.04	6.95	218.7
0.10	0.02	5.00	177.2
0.65•	0.16•	16.7•	212.3
0.61•	0.14•	16.0•	
0.12	0.03	7.87	201.8
0.13	0.03	9.07	213.2
0.15	0.04	3.39	187.2
2.28•	0.32•	26.9•	233.4
2.17•	0.32•	24.3•	
0.03	0.01	0.69	176.1
0.56	0.11	11.5	202.1
1.58	0.40	22.4	224.5
1.29	0.29	19.6	229.4
0.48•	0.09•	16.1•	163.2
0.53•	0.09•	15.8•	
0.61	0.11	20.1	197.7
0.62	0.11	17.1	175.0
0.44	0.09	15.4	163.0
1.07	0.20	15.8	202.0
0.57•	0.07•	16.5•	181.4
0.55•	0.07•	16.1•	
1.62	0.29	12.1	216.8
0.88	0.16	18.2	244.6
1.04	0.18	12.9	210.1
Herring T [1]			
1.02	0.16	13.7	186.7
0.60•	0.11•	10.1•	210.9
0.50•	0.09•	9.38•	
Perch 2 [2]			
0.11	TR	0.13	11.51
0.12	TR	0.59	6.92
0.08	TR	0.14	6.98
0.07	0.01	0.16	10.10
0.09	TR	0.41	7.32
0.16	TR	0.19	6.65
0.08	0.01	0.25	7.38
0.07	TR	0.26	9.34
0.06	TR	0.28	10.10
0.22	TR	0.44	7.91
0.12	TR	0.31	8.73
0.05	TR	0.28	10.40
0.04	TR	0.29	13.41
0.09	TR	0.50	5.65
0.07	TR	0.34	9.32
0.06	TR	0.76	9.49
0.05	0.01	0.32	13.16
0.06	TR	0.30	9.74
0.08	TR	0.29	10.91
0.07	TR	0.19	8.27
0.05	TR	0.23	13.04
0.09	0.01	0.14	8.95
0.10	0.01	0.34	8.04
0.05	TR	0.29	12.15
0.12	TR	0.74	5.72
Perch 3 [3]			
0.09	0.13	1.42	
0.14	0.10	0.87	
0.04	0.06	0.39	
0.05	0.05	0.67	
0.16	0.10	0.47	
0.06	0.08	0.69	
0.11	0.14	0.33	
0.18	0.17	0.35	
0.27	0.19	0.70	
0.11	0.07	0.57	
0.14	0.04	0.56	
0.29	0.13	0.91	
0.26	0.24	0.47	
0.14	0.10	0.40	
0.10	0.06	0.35	
0.12	0.09	0.88	
0.22	0.15	0.44	
0.07	0.05	0.37	
0.09	0.10	0.34	
0.13	0.14	0.44	
0.10	0.09	0.31	
0.07	0.08	0.37	
0.13	0.03	0.41	
0.11	0.07	0.48	
0.19	0.06	0.50	

NOTE: • = duplicate analyses of a single specimen. TR = trace: <0.01.
[1] Herring samples represented 24 individual fish.
[2] Perch samples represented 25 individual fish.
[3] Weights not available for perch sample 3.

tar to yield a free-flowing powder and extracted with pesticide-grade hexane (Fisher Scientific H-300) in a Soxhlet extractor for 1 hour. The volume of the extract was adjusted to 100 ml in a volumetric flask with pesticide-grade hexane. An aliquot of the extract (10-20 ml) was dried in a rotatory evaporator in vacuum at room temperature to determine hexane-extractable lipids. An aliquot, not exceeding 100 mg of lipids, was applied in 1.5 ml pesticide-grade hexane to a 45-by-0.7-cm glass column with a glass wool plug, containing 2 g alumina, Fisher Scientific A-540, activated at 800°C for 4 hours and deactivated by the addition of 5 percent distilled water. The solvent was washed into the column with another 1.5 ml pesticide-grade hexane and the column was percolated with the same solvent to collect 20 ml effluent.

After the effluent had been concentrated almost to dryness on a rotatory evaporator, it was applied in 1.5 ml 0.5 percent v/v pesticide-grade benzene (Fisher Scientific B-426) in pesticide-grade hexane to a column

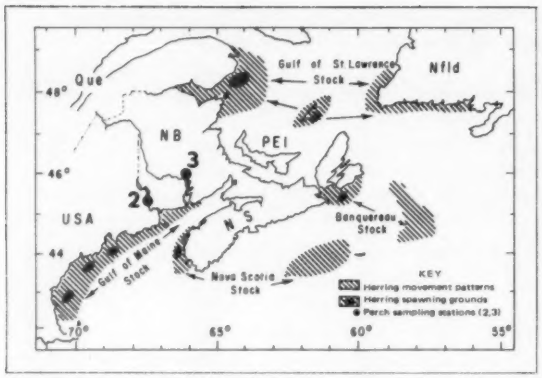

FIGURE 1. *Atlantic herring stock structure and yellow perch sampling stations—Eastern Canada, 1972*

filled with silica. The column was the same as that described above, and contained 2 g Mallinckrodt Silica: 100-200 mesh. The solvent was washed with pesticide-grade hexane, dried in a rotatory evaporator at 36°C in vacuum, activated overnight at 130°C, and deactivated by the addition of 3 percent distilled water. The applied aliquot was washed into the column with another 1.5 ml of the solvent. The column was percolated with the same solvent to collect 15 ml effluent. This fraction contained PCB's and *p,p'*-DDE.

The column was percolated further with 10 percent diethyl ether (Fisher Scientific E-134) in hexane and 10 ml effluent was collected. This fraction contained *p,p'*-DDD and *p,p'*-DDT. Fractions were evaporated just to dryness on a rotatory evaporator in vacuum at room temperature. The residue was dissolved in pesticide-grade hexane (0.2-0.4 ml) and analyzed by gas chromatography. The gas chromatograph, a Packard A7901, was operated at 200°C. It had a glass column (6 ft by 4 mm), containing 4 percent SE-30 on acid-washed Chromosorb W, 60-80 mesh. Carrier gas was nitrogen at a flow rate of 60 ml/min. Injector and detector (^{3}H, 150 mc) were kept at 210°C. A solution of Aroclor 1254 (2.232 µg/ml) and a solution containing *p,p'*-DDE, *p,p'*-DDD, and *p,p'*-DDT (0.182, 0.235, and 0.247 µg/ml, respectively) were used daily to calibrate the detector. Heights of five of the six major peaks of Aroclor 1254 were used for quantitation. Peak heights were also used to quantitate the other compounds. Minimum detectable levels of PCB's, *p,p'*-DDE, *p,p'*-DDD, and *p,p'*-DDT were 0.01, 0.003, 0.002, and 0.002 µg/g wet weight, respectively.

All glassware was washed with a laboratory detergent in tap water and rinsed with distilled water, acetone, and pesticide-grade hexane. Sodium sulfate was washed with pesticide-grade hexane and dried in a rotatory evaporator at 36°C in vacuum. Extraction thimbles and glass wool were pre-extracted with pesticide-grade hexane in a Soxhlet extractor. In preparing the 0.5 percent v/v benzene in pesticide-grade hexane, an allowance was made for benzene already present in hexane. The concentration of benzene in each batch of pesticide-grade hexane was determined from the absorbence at 253 nm against spectrograde hexane (Fisher Scientific H-334).

In each sample, 24 herring and 25 perch were analyzed individually. Five fish from each sample were analyzed in duplicate, including duplicate extraction. Results of duplicate analyses usually agreed within 10 percent and arithmetic means of duplicate analyses were used in further evaluation of data.

DATA EVALUATION

Arithmetic means and standard deviations (Tables 1-6) were calculated from the data (Table 7) and from their decadic logarithms. To determine whether distribution of data can be approximated by a normal or a lognormal distribution, data were divided into classes; enough classes were chosen to assure that the original mean and standard deviation would not alter appreciably. Frequencies expected for normal and lognormal distribution were calculated from the means and standard deviations and compared with observed frequencies, testing the goodness of fit by the chi square test *(6)*. Higher chi square probabilities (Tables 1,2,4,5) indicate better fit of the theoretical to the observed distribution.

Results and Discussion

PCB'S

In all samples PCB's resembled and were quantitated as Aroclor 1254. Data are summarized in Table 1. As can be seen from the chi square probability, in three out of four cases lognormal distribution would be preferred to normal. PCB distribution in the herring sample T could not be adequately characterized by either distribution. The PCB level reported previously *(3)* for the Banquereau stock of similar weight group (arithmetic mean 0.54) falls between the levels observed in the Nova Scotia and Gulf of St. Lawrence stocks. This may indicate that the level of PCB's in herring of equal size decreases in the northerly direction.

CHLORINATED HYDROCARBON PESTICIDES

Levels of *p,p'*-DDE are presented in Table 2. DDE was not detectable in perch sample 2. In all cases, the distribution is better described as lognormal. Levels of *p,p'*-DDD and *p,p'*-DDT in herring are summarized in Table 3. Because of the low levels found, no detailed statistical evaluation of the data was made and it was assumed that, as in the case of *p,p'*-DDE, the distribution is lognormal. No measurable residues of *p,p'*-DDD and *p,p'*-DDT were found in perch sample 2. Perch sample 3 contained very low levels of these compounds

(0.005-0.02 μg/g) in six fish analyzed individually. Statistical evaluation was not carried out.

LIPID AND BODY WEIGHT

In three out of four cases the distribution of lipid was best described as lognormal (Table 4). Herring sample T may be described by a normal distribution. This was the only sample taken at the end of the feeding season and it is possible that there is a relation between the feeding activity and the distribution of lipid. The weight of the fish was normally distributed (Table 5), with the exception of herring sample T, where the data may be described by a lognormal distribution. Weights were not available for perch sample 3.

TRENDS OF PCB AND *p,p'*–DDE LEVELS

Knowing the trends of the environmental levels of persistent pollutants enables one to assess the effectiveness of regulatory actions such as the Canadian ban on DDT and restriction of PCB's. As stated earlier, one objective of this study was to weigh the possibility of using Atlantic herring and yellow perch to detect such trends. Authors' findings now render that possibility obscure. Analytical data indicate that even after elimination of possible sex and age (or size) variations, the variability between individual fish still remains very high and a large number of fish have to be analyzed to detect statistically significant differences. Table 6 calculates differences for the 5 percent probability level, using the observed standard deviations and assuming that 25 individual fish are analyzed in each sample.

It is very likely that no significant difference in PCB levels can be detected in 2 consecutive years when using samples of this size. Concentration of PCB's in fish is determined by the rate of PCB uptake and excretion and by the growth of fish. The rate of excretion is very slow. In related studies fish did not metabolize chlorobiphenyl isomers *(7)* and excreted very little, if any, Aroclor 1254 ingested in a laboratory experiment *(8)*. If, in a hypothetical case, the uptake of PCB's were completely eliminated, concentration of PCB's in fish would depend only on the rate of growth. The relative weight increase of the investigated stocks of herring between the age of 3 and 4 years is approximately 46 percent and the level of PCB's in 3-year-old fish is about 86 percent of that in 4-year-old fish *(9)*. The concentration of PCB's in 4-year-old herring in 1974 would therefore be 59 percent of the level in herring of the same age in 1973. This hypothetical level is quite close to the minimum detectable difference in Table 6. The uptake of PCB's cannot be completely eliminated due to the presence of PCB's in the environment; the difference will be smaller than estimated above. It may be more pertinent and less costly to analyze a large number of individual fish only every 4-5 years to determine trends of PCB levels.

Insufficient data on the excretion rate of *p,p'*-DDE by fish do not allow prediction of trends of *p,p'*-DDE levels. It is possible that *p,p'*-DDE residues disappear from fish faster than PCB residues. The average level of *p,p'*-DDE in the Banquereau herring in 1971 was 0.24 μg/g *(3)* and the levels of *p,p'*-DDE in herring oils in 1968-70 were comparable to those of PCB's *(4)*. Levels of *p,p'*-DDE reported in this paper are much lower.

Acknowledgments

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RESIDUES IN FOOD AND FEED

Pesticide Residues in Total Diet Samples (VII)

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ABSTRACT

Pesticide residue levels detected in ready-to-eat foods remained at relatively low levels during the seventh year of the Total Diet Study in its present form. Samples were collected from 30 markets in 27 different cities. Populations of cities ranged from less than 50,000 to 1,000,000 or more. Averages and ranges of pesticides commonly found are reported for the period June 1970-April 1971 by region and food class. Pesticides found infrequently are also reported for this period by region and food class. Results of recovery studies with various classes of pesticides are also presented. After October 1970, analyses of bromides, amitrole, and dithiocarbamates were discontinued; mercury and orthophenylphenol were added. Residue levels in three major fatty food groups are now reported on a whole-product basis, rather than on a fat basis. Data for June and August were adjusted accordingly.

Introduction

The Total Diet Program *(1)* has been used since 1964 by the Food and Drug Administration (FDA), U.S. Department of Health, Education, and Welfare, as a way to monitor pesticide residues in foods. This program measures the amount of pesticide chemicals in food samples collected in retail outlets and prepared for consumption. Although the program was designed to measure pesticide residues in foods, some chemicals determined and reported here may not have been used as pesticides; this includes such materials as polychlorinated biphenyls (PCB's), cadmium, and mercury. Increased awareness of the potential hazards presented by these chemicals necessitates their inclusion in this program.

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Amounts and types of residues found from June 1964 through April 1970 have been described in earlier reports *(2-7)*. The present report covers the period June 1970 through April 1971. Tabular data included are comparable to those of previous years.

Analytical Methods

No significant changes were made in sampling and compositing procedures described in the initial issue of *Pesticides Monitoring Journal (1)*. Samples were collected in 30 different grocery markets in 27 different cities representing five regions of the United States: Baltimore, Boston, Kansas City, Los Angeles, and Minneapolis. Population of the cities ranged from less than 50,000 to 1,000,000 or more; the average sampling site was in the 250,000 to 500,000 range.

Beginning with the October 1970 sample, significant changes were made regarding analysis. At that time, all Total Diet analyses were centralized at the FDA Kansas City district. Analyses for bromides, amitrole, and dithiocarbamates were discontinued, and PCB's, mercury, and orthophenylphenol (*o*-phenylphenol) were added. Analyses for residues of organochlorines, some parent organophosphorus pesticides, chlorophenoxy acid herbicides, carbaryl, arsenic, and cadmium were continued as in previous programs.

Procedural changes were made in analyses of fatty food groups for chlorinated and organophosphorus residues. These food groups were Group I: Dairy Products; Group II: Meat, Fish, and Poultry; and Group X: Oils, Fats, and Shortening. Prior to October 1970, all organochlorine and organophosphorus residues found in these three groups were reported on a fat basis. After this date, residues were calculated on a whole-product basis. Results reported here from June and August samples have been converted to the whole-product basis using

an average fat content of 10.5 percent for Group I, 20 percent for Group II, and 85.5 percent for Group X.

Methods used for most analyses are described in the FDA Pesticide Analytical Manual, Vol. I and II *(8)*. Other analytical methodology was used for certain residues: colorimetry for arsenic *(9)*; flameless atomic absorption spectroscopy for mercury *(10)*, and atomic absorption or polarography for cadmium *(11)*. Carbaryl and *o*-phenylphenol were extracted by the method of Porter et al. *(12)* and quantified by thin-layer chromatography (TLC) *(13)*.

Quantitative values reported for organochlorine and organophosphorus compounds were obtained by gas-liquid chromatography (GLC) using the electron capture, the thermionic, or the flame photometric detection system. Confirmation was made by TLC and/or GLC with halogen-specific microcoulometric detection. For additional confirmation of residues, identity techniques such as *p*-values, alternative GLC column packings, alkaline hydrolysis, and mass spectrometry were used.

The methodology permits the quantitation of heptachlor epoxide, an organochlorine, at about 0.003 parts per million (ppm), and of parathion, an organophosphate, at about 0.01 ppm. The limit of quantitation for both classes varies with the individual compound being determined. In some cases, finite residue levels are reported below the approximate limits of quantitation. The quantitative reliability of these extremely low levels is not known because the authors have no recovery information about dietary composites below 0.003 ppm for organochlorine compounds or 0.01 ppm for organophosphorus compounds. As a general rule residue determinations below 0.005 ppm are subject to a high degree of variability. Those residues detected and qualitatively confirmed at too low a level to be quantified are reported as trace (T).

Approximate limits of quantitation for other analyses were chlorophenoxy acid herbicides and pentachlorophenol (PCP): 0.02 ppm; carbaryl: 0.05 ppm; arsenic: 0.1 ppm; cadmium: 0.01 ppm; amitrole (June and August samples only): 0.05 ppm; bromides (June and August samples only): 0.5 ppm. Individual fruits and vegetables were examined for dithiocarbamate residues (June and August samples only). Beginning in October 1970, each composite was examined for PCB's with a limit of quantitation of about 0.05 ppm; for *o*-phenylphenol, with a limit of 0.1 ppm; and for mercury, with a limit of 0.02 ppm.

Results

A total of 1,081 residues of 33 different chemicals were found in samples in the current reporting period. In the previous reporting period, 1,446 occurrences of 31 different chemicals were found. This apparently large decrease is deceptive; almost one-half the decrease occurred in reported bromide residues because bromide analyses were discontinued in October 1970. As in previous years, a total of 360 composites were examined for all residues; there were 12 composites from each of the 30 markets. The program calls for carbaryl and *o*-phenylphenol analyses on only the nonfatty composites *(1,3-6,9-11,13)*, of which there were 270. Program changes also resulted in analyses of only 240 composites for mercury and 120 composites for bromides. The 33 different residues found are listed in decreasing order of frequency in Table 1.

The most common residues, maximum levels of those residues, and residues reported less frequently are discussed below for each of the 12 food composites. Tables 2a and 2b report findings in more detail according to food class and region. None of the reported findings have been corrected for recoveries obtained in recovery experiments. Table 3 summarizes studies.

DAIRY PRODUCTS

Of the 30 composites examined, 28 contained residues. Organochlorine pesticide residues were the most common, appearing in 27 composites. The most common organochlorines and their maximum concentrations were DDT, 0.005 ppm; DDE, 0.028 ppm; dieldrin, 0.007 ppm; heptachlor epoxide, 0.001 ppm; and BHC, 0.001 ppm. Also found were hexachlorobenzene (HCB), lindane, TDE, methoxychlor, and PCP. Bromides were found in 7 of 10 composites examined at levels of 1.0 ppm to 5.5 ppm. Cadmium was found in 4 of 30 composites at 0.01 to 0.06 ppm.

MEAT, FISH, AND POULTRY

Residues of 9 organochlorine compounds were found in varying combinations in all 30 composites examined. Most common organochlorine residues and their maximum concentrations were DDE: 0.048 ppm; DDT: 0.033 ppm; TDE: 0.010 ppm; and dieldrin: 0.015 ppm. Heptachlor epoxide, lindane, BHC, bromides, and HCB were also found, although less frequently. PCB's were found in 14 of the 30 composites; the highest PCB residue was 0.15 ppm. Arsenic was found in 9 composites: 0.1-0.3 ppm; and cadmium was found in 17 composites: 0.01-0.04 ppm.

GRAIN AND CEREAL PRODUCTS

Organophosphorus residues were the most common found in this commodity class. Malathion was found in 28 of 30 composites (maximum level 0.170 ppm); diazinon was found in 12 of 30 composites (maximum level 0.015 ppm). Varying combinations of 8 organochlorine compounds were found in 20 of 30 composites. The most common organochlorines and their maximum levels found were DDE: 0.001 ppm; DDT: 0.009 ppm; and dieldrin: 0.012 ppm. PCB's were found in 4 composites; 0.36 ppm was the highest level reported.

Cadmium was found in 27 of 30 composites at 0.01-0.07 ppm. Other residues found were TDE, ronnel, *o*-phenylphenol, and methoxychlor.

POTATOES

Residues of 8 organochlorine compounds were detected in 15 of the 30 composites. The most common of

TABLE 1. *Insecticide residues found in food composites, June 1970-April 1971* [1]

Chemical Found	No. of Composites with Residues	No. of Positive Composites with Residues Reported As Trace [2]	Ranges of PPM Reportings
CADMIUM	213	0	0.01-0.20
DDE 1,1-dichloro-2,2-bis (*p*-chlorophenyl) ethylene (isomers other than *p,p'* also included in reportings)	133	55	T-0.028
DDT 1,1,1-trichloro-2,2-bis (*p*-chlorophenyl) ethane (isomers other than *p,p'* also included in reportings)	118	51	T-0.037
DIELDRIN Not less than 85% of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene	110	23	T-0.015
TDE 1,1-dichloro-2,2-bis (*p*-chlorophenyl) ethane (isomers other than *p,p'* also included in reportings)	90	42	T-0.087
BROMIDES [1]	81	0	0.5-51
MALATHION diethylmercaptosuccinate, *S*-ester with *0,0*-dimethyl phosphorodithioate	49	2	T-0.170
BHC 1,2,3,4,5,6-hexachlorocyclohexane, mixed isomers except gamma	42	19	T-0.009
HEPTACHLOR EPOXIDE 1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindan	36	23	T-0.011
LINDANE 1,2,3,4,5,6-hexachlorocyclohexane, 99% or more gamma isomer	28	8	T-0.023
ENDOSULFAN 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide (reportings include isomers I,II, and the Sulfate)	24	8	T-0.063
CARBARYL [1]	20	15	T-0.5
PCB'S (polychlorinated biphenyls) Calculated as Aroclor® with varied chlorine content—54% and 60% reported this period	18	13	T-0.36
DIAZINON *0,0*-diethyl *0*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate	15	10	T-0.015
ETHION *0,0,0',0'*-tetraethyl *S,S'*-methylene bisphosphorodithioate	15	3	T-0.099
ARSENIC (As_2O_3)	13	0	0.1-0.3
DICOFOL (KELTHANE®) 4,4'-dichloro-a-(trichloromethyl) benzhydrol	13	2	T-0.066
PARATHION *0,0*-diethyl *0*-*p*-nitrophenyl phosphorothioate	11	4	T-0.012
ORTHOPHENYLPHENOL [1] 2-hydroxydiphenyl	10	7	T-0.25
MERCURY [1]	10	3	T-0.05
HCB hexachlorobenzene	6	3	T-0.001
PERTHANE 1,1-dichloro-2,2-bis (*p*-ethyl phenyl) ethane	5	2	T-0.022
METHOXYCHLOR 1,1,1-trichloro-2,2-bis (*p*-methoxyphenyl) ethane	4	2	T-0.008
METHYL PARATHION *0,0*-dimethyl *0*-*p*-nitrophenyl phosphorothioate	3	2	T-0.011
2,4-D 2,4-dichlorophenoxyacetic acid	3	0	0.01-0.02
PENTACHLOROPHENOL	2	1	T-0.011
BOTRAN® 2,6-dichloro-4-nitroaniline	2	0	0.003-0.006
ENDRIN 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-endo*-5,8-dimethanonaphthalene	2	1	T-0.007
TOXAPHENE chlorinated camphene containing 67-69% chlorine	1	1	T
DCPA (DACTHAL®) 2,3,5,6-tetrachloroterephthalic acid dimethyl ester	1	1	T
CIPC isopropyl *n*-(3-chlorophenyl) carbamate	1	0	0.14
PHOSALONE *S*[(6-chloro-2-oxo-3-benzoxazolinyl)] methyl *0,0*-diethyl phosphorodithioate	1	0	0.278
RONNEL *0,0*-dimethyl *0*-2,4,5-trichlorophenyl phosphorothioate	1	0	0.007

[1] Total of 360 composites examined for each compound except as follows: mercury—240 composites; bromides—120 composites; carbaryl and orthophenylphenol—270 composites.

[2] Pesticide chemicals capable of being detected by the specific analytical methodology may be confirmed qualitatively but are not quantifiable when they are present at concentrations below the limit of quantitation. Limit of quantitation varies with residue and food class.

these were dieldrin, DDE, and DDT with maximum values of 0.006 ppm, 0.018 ppm, and 0.020 ppm, respectively. Also detected were Botran (dichloran), TDE, BHC, endrin, carbaryl, endosulfan, CIPC (chlorpropham), bromides, and arsenic. Cadmium was found in 28 of 30 composites at 0.02-0.09 ppm.

LEAFY VEGETABLES

Residues of 9 organochlorine compounds were found in varying combinations in 23 of 30 composites. Organophosphorus residues were found in 10 of 30 composites. The most common residues and their maximum levels were DDT: 0.026 ppm; endosulfan: 0.063 ppm; parathion: 0.012 ppm; DDE: 0.016 ppm; and dieldrin: 0.005 ppm. Cadmium (0.01-0.20 ppm) was found in 28 of 30 composites examined. Other residues found were methyl parathion, carbaryl, diazinon, 2,4-D, bromides, HCB, TDE, Dacthal (DCPA), and malathion.

LEGUME VEGETABLES

Residues of 5 organochlorine compounds were found in 7 of 30 composites. DDE and DDT were most common, with maximum values of 0.005 ppm and 0.031 ppm, respectively. Other residues found were TDE, carbaryl, BHC, dieldrin, parathion, cadmium, and bromides.

ROOT VEGETABLES

Of 30 composites, 11 were found to contain 6 different organochlorine residues in varying combinations. The most common residues found and maximum levels detected were DDE: 0.006 ppm; and DDT: 0.008 ppm. Cadmium was discovered in 24 of 30 composites at 0.01-0.06 ppm. Other residues were dieldrin, TDE, *o*-phenylphenol, lindane, toxaphene, carbaryl, and bromides.

GARDEN FRUITS

Residues of 8 organochlorine compounds were found in varying combinations in 28 of 30 composites. The most common of these and the maximum levels were TDE: 0.087 ppm; DDT: 0.037 ppm; dieldrin: 0.010 ppm; and BHC: 0.009 ppm. Cadmium was found in 26 of 30 composites at 0.01-0.05 ppm. Other residues detected were parathion, *o*-phenylphenol, DDE, carbaryl, endosulfan, bromides, lindane, and Kelthane (dicofol).

FRUITS

Residues of 9 organochlorine compounds were found in 19 of 30 composites. The most common of these and the maximum levels found were DDE: 0.002 ppm; Kelthane: 0.066 ppm; and DDT: 0.003 ppm. Residues of 5 organophosphorus compounds were found in varying combinations in 20 of 30 composites. The most common and the highest levels found were ethion: 0.099 ppm; and malathion: 0.089 ppm. Other residues found included TDE, *o*-phenylphenol, carbaryl, perthane, endosulfan, phosalone, lindane, diazinon, dieldrin, Botran, arsenic, cadmium, and bromides.

OILS, FATS, AND SHORTENING

Residues of 4 organochlorine compounds were found in varying combinations in 24 of 30 composites. The residues and their maximum levels were dieldrin: 0.006 ppm; DDE: 0.008 ppm; TDE: 0.013 ppm; and DDT: 0.012 ppm. Malathion was found in 12 composites; maximum level was 0.097 ppm. Cadmium appeared in 27 of 30 composites at levels of 0.01 to 0.04 ppm. Bromides were detected in 5 composites at a maximum of 12.0 ppm.

SUGARS AND ADJUNCTS

Residues of 7 organochlorine compounds were found in varying combinations in 15 of 30 composites. The most common organochlorines and their maximum levels were lindane: 0.004 ppm; DDT: 0.017 ppm; and DDE: 0.002 ppm. Heptachlor epoxide, BHC, PCP, diazinon, malathion, arsenic, and bromides were also detected. Cadmium (0.01-0.03 ppm) was found in 14 of 30 composites.

BEVERAGES

Of all food composites studied, beverages had the lowest amounts of pesticides; only 9 of 30 composites contained any residues. DDT, TDE, and lindane each appeared in 1 composite, cadmium appeared in 3 composites, and bromides appeared in 5. All residues were at or near trace levels.

Discussion

Organochlorine residues were found in 221 of 360 composites, or 61.4 percent of those examined. Corresponding percentages from previous years were 74.2 percent in 1969-70, 64.7 percent in 1968-69, and 65.6 percent in 1967-68. Organophosphorus compounds in the current reporting period were found in 77 composites or 21.4 percent. The three previous reporting periods showed 74, 59, and 26 composites, respectively, which had organophosphorus residues.

Carbaryl was found in 20 composites during this reporting period; 15 of these findings were at trace levels. This is in contrast to the June 1969-April 1970 period *(4)*, which showed no carbaryl, and to the June 1968-April 1969 period *(3)*, which showed only three positive composites. However, it should be noted that during the two previous periods the fruit and vegetable composites were examined both before and after processing. Foods were processed in the usual manner: peeling, stripping outer leaves, cooking when appropriate, etc. This dual analysis was conducted only during the two previous reporting periods, serving as an indicator of

residue loss through preparation of foods for table-ready consumption. Carbaryl loss through such processing was not presented in earlier reports because of its low frequency and level of occurrence. However, carbaryl did occur as indicated in the following paragraph. Findings are presented as parts per million in both the unprocessed composite and in the diet-prepared composite; ND signifies no residues detected, TR signifies trace residues detected.

June 1969-April 1970	Unprocessed	Diet-prepared
Group VI, Legume Vegetables, 30 composites examined	0.13 ppm	ND
Group VII, Root Vegetables, 30 composites examined	0.14 ppm	ND
June 1968-April 1969		
Group VI, Legume Vegetables, 25 composites examined	0.5 ppm	TR
	TR	TR
Group IX, Fruits, 25 composites examined	0.4 ppm	ND
	0.2 ppm	ND
	0.3 ppm	0.3 ppm

It appears that normal preparation of foods for human consumption generally renders carbaryl residues below detection levels, or very near that point. Accordingly, it is difficult to define the significance of the apparent increase in incidence during this reporting period because the majority of findings were at trace levels.

Analysis for *o*-phenylphenol was included this reporting period because it is detectable simultaneously with the carbaryl; *o*-phenylphenol was found in 10 composites.

Arsenic residues were found in 13 composites at concentrations from 0.1 ppm to 0.3 ppm. Of these arsenic findings, nine were in Group II: Meat, Fish, and Poultry.

Cadmium was found in 213 of 360 composites; maximum level was 0.20 ppm.

No amitrole or dithiocarbamate residues were found during this reporting period. Chlorophenoxy acid herbicides (2,4-D) were found in three leafy vegetable composites. PCP, which is detected by the chlorophenoxy acid methodology, was reported in two composites. Previous reportings showed chlorophenoxy acid herbicides in four composites in 1969-70, and four in 1968-69.

Mercury residues were found in 10 of 240 composites. All mercury residues were found in Group II: Meat, Fish, and Poultry. Analyses of individual commodities within Group II have shown that the principal source of mercury in the diet is seafood.

Recovery studies were conducted for all classes of chemicals sought throughout the entire year. Table 3 lists recovery data for this reporting period for 14 of the more commonly found organochlorine residues and data for representative compounds in the other chemical classes. Each recovery experiment consisted of a single determination for the unfortified food composite and a single determination for the fortified sample. Since these were performed simultaneously, the fortification level was occasionally below the level present in the sample. In other cases, not enough recoveries were run to permit statistical evaluation. These recovery data are not reported.

At very low fortification levels recoveries may range from 0 to 200 percent. As the fortification level is raised, however, the recovery improves. Based on recovery data, it is apparent that individual, low-level residues reported may vary from the so-called true value but the overall findings are useful in appraising the national residue picture.

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TABLE 2A. *Levels of pesticide residues commonly found—by food class and region, June 1970-April 1971*

Chemical	Baltimore	Boston	Kansas City	Los Angeles	Minneapolis
I. Dairy Products [1] Residues, ppm					
DDT					
Average	T	0.001	0.001	T	T
Positive Composites					
Number	1	3	3	3	1
Range	0.001	T-0.005	T-0.003	T-0.002	0.001
DDE					
Average	T	T	T	0.019	T
Positive Composites					
Number	4	5	3	6	2
Range	T-0.001	T-0.002	T-0.001	0.010-0.028	0.001
DIELDRIN					
Average	T	0.002	0.003	0.001	0.003
Positive Composites					
Number	3	5	5	6	5
Range	T-0.002	0.001-0.003	T-0.007	T-0.002	0.001-0.005
BHC					
Average	T	T	T	T	T
Positive Composites					
Number	1	4	4	2	3
Range	T	T-0.001	T-0.001	T	T-0.001
HEPTACHLOR EPOXIDE					
Average	T	T	T	T	T
Positive Composites					
Number	2	5	3	2	3
Range	T	T	T-0.001	T-0.001	T-0.002
II. Meat, Fish, and Poultry [1] Residues, ppm					
TDE					
Average	0.003	0.003	0.004	T	0.001
Positive Composites					
Number	3	5	4	3	5
Range	T-0.009	T-0.010	T-0.019	T	T-0.002
DDT					
Average	0.005	0.009	0.013	0.005	0.004
Positive Composites					
Number	5	6	6	5	6
Range	T-0.015	T-0.018	T-0.033	T-0.011	T-0.008
DDE					
Average	0.007	0.007	0.006	0.033	0.007
Positive Composites					
Number	6	6	6	6	6
Range	0.001-0.014	T-0.021	0.003-0.013	0.018-0.048	T-0.022
DIELDRIN					
Average	0.003	0.005	0.005	0.003	0.003
Positive Composites					
Number	4	4	6	6	5
Range	T-0.008	0.001-0.015	0.004-0.009	0.001-0.004	0.002-0.007
PCB'S					
Average	T	T	T	T	0.029
Positive Composites					
Number	4	2	2	2	4
Range	T	T	T	T	T-0.15
CADMIUM					
Average	0.01	0.01	< 0.01	0.01	0.01
Positive Composites					
Number	3	4	3	2	5
Range	0.01-0.02	0.01-0.04	0.01-0.02	0.01	0.01-0.02
ARSENIC					
Average	< 0.1	< 0.1	< 0.1	< 0.1	—
Positive Composites					
Number	2	3	2	2	0
Range	0.1-0.2	0.1-0.3	0.1-0.2	0.2-0.3	—
HEPTACHLOR EPOXIDE					
Average	T	T	0.002	T	T
Positive Composites					
Number	3	5	3	2	5
Range	T-0.003	T	0.001-0.011	T-0.001	T-0.001
MERCURY					
Average	< 0.02	< 0.02	< 0.02	0.02	< 0.02
Positive Composites					
Number	1	3	1	3	2
Range	< 0.02	T-0.03	< 0.02	0.02-0.05	0.02

(Continued next page)

TABLE 2A (cont'd). *Levels of pesticide residues commonly found—by food class and region, June 1970-April 1971*

CHEMICAL	BALTIMORE	BOSTON	KANSAS CITY	LOS ANGELES	MINNEAPOLIS
III. GRAIN AND CEREAL [1] RESIDUES, PPM					
DDT					
Average	T	0.001	—	0.002	0.001
Positive Composites					
Number	2	3	0	2	3
Range	T	T-0.005	—	T-0.009	T-0.003
MALATHION					
Average	0.023	0.015	0.016	0.062	0.030
Positive Composites					
Number	6	5	5	6	6
Range	0.008-0.038	0.013-0.023	0.011-0.026	0.020-0.170	0.015-0.041
DIELDRIN					
Average	0.002	T	T	0	T
Positive Composites					
Number	1	1	1	0	1
Range	0.012	0.001	T	—	T
DIAZINON					
Average	0.001	0	0.001	0.003	T
Positive Composites					
Number	2	0	4	4	2
Range	T-0.006	—	T-0.006	T-0.015	T-0.002
CADMIUM					
Average	0.02	0.03	0.02	0.02	0.03
Positive Composites					
Number	5	5	5	6	6
Range	0.01-0.03	0.01-0.07	0.01-0.04	0.01-0.02	0.02-0.03
PCB'S					
Average	0	0.06	T	0.18	0.14
Positive Composites					
Number	0	1	1	1	1
Range	—	0.36	T	0.36	0.82
BROMIDES					
Average	7.8	4.8	5.0	2.7	2.4
Positive Composites					
Number	2	2	1	2	1
Range	22-25	14	30	7.0-9.0	14
LINDANE					
Average	0	0	0	0.001	T
Positive Composites					
Number	0	0	0	2	1
Range	—	—	—	0.003-0.005	0.001
DDE					
Average	T	T	0	0	T
Positive Composites					
Number	2	1	0	0	3
Range	T	T	—	—	T-0.001
IV. POTATOES [1] RESIDUES, PPM					
DDT					
Average	0.003	0.001	0	T	T
Positive Composites					
Number	1	2	0	1	T
Range	0.020	T-0.004	—	T	0.002
DIELDRIN					
Average	0.001	T	0.001	T	0.001
Positive Composites					
Number	1	2	3	2	2
Range	0.005	T	T-0.003	T-0.001	0.001-0.006
DDE					
Average	0.001	T	0.004	T	T
Positive Composites					
Number	1	2	2	1	2
Range	0.007	T	0.003-0.018	T	T-0.002
CADMIUM					
Average	0.04	0.03	0.04	0.03	0.05
Positive Composites					
Number	5	5	6	6	6
Range	0.02-0.08	0.02-0.04	0.02-0.08	0.02-0.04	0.02-0.09

(Continued next page)

TABLE 2A (cont'd). *Levels of pesticide residues commonly found—by food class and region, June 1970-April 1971*

CHEMICAL	BALTIMORE	BOSTON	KANSAS CITY	LOS ANGELES	MINNEAPOLIS
V. LEAFY VEGETABLES [1] RESIDUES, PPM					
DDT					
Average	0.004	0.001	0.001	0.002	T
Positive Composites					
Number	1	5	1	3	1
Range	0.026	T-0.004	0.008	T-0.008	0.002
DDE					
Average	0.003	0.003	0	0.063	0.002
Positive Composites					
Number	2	3	0	4	3
Range	0.004-0.016	T-0.011	—	T-0.008	0.002-0.006
ENDOSULFAN (I, II plus sulfate)					
Average	0.001	0.006	0.003	0.013	0.007
Positive Composites					
Number	1	4	4	4	2
Range	0.006	T-0.020	T-0.008	0.063	0.001-0.018
CADMIUM					
Average	0.03	0.06	0.02	0.05	0.08
Positive Composites					
Number	6	6	4	6	6
Range	0.01-0.05	0.02-0.14	0.02-0.03	0.03-0.08	0.02-0.20
PARATHION					
Average	.002	0.005	T	T	0
Positive Composites					
Number	1	4	1	1	0
Range	0.01	T-0.012	T	0.002	—
VI. LEGUME VEGETABLES [1] RESIDUES, PPM					
DDT					
Average	0	0.006	0	T	0
Positive Composites					
Number	0	2	0	3	0
Range	—	0.003-0.031	—	T-0.002	—
DDE					
Average	0	0.001	0	0.001	0
Positive Composites					
Number	0	2	0	3	0
Range	—	T-0.004	—	T-0.005	—
CADMIUM					
Average	0.007	0.007	0.007	0.003	0.003
Positive Composites					
Number	3	2	3	1	2
Range	0.01-0.02	0.02	0.01-0.02	0.01	0.01
VII. ROOT VEGETABLES [1] RESIDUES, PPM					
DDT					
Average	0	0.001	0	T	0
Positive Composites					
Number	0	2	0	2	0
Range	—	T-0.008	—	T-0.001	—
DDE					
Average	0	0.001	0.001	T	0.001
Positive Composites					
Number	0	1	1	3	1
Range	—	0.005	0.006	T-0.002	0.005
CADMIUM					
Average	0.02	0.02	0.01	0.03	0.02
Positive Composites					
Number	6	5	2	5	6
Range	0.01-0.02	0.01-0.04	0.02-0.05	0.01-0.06	0.01-0.03

(Continued next page)

TABLE 2A (cont'd). *Levels of pesticide residues commonly found—by food class and region, June 1970-April 1971*

Chemical	Baltimore	Boston	Kansas City	Los Angeles	Minneapolis
VIII. Garden Fruits [1]					
Residues, ppm					
DDT					
Average	0.006	0.005	0.007	0.008	0.004
Positive Composites					
Number	2	2	3	3	1
Range	0.014-0.023	0.006-0.025	T-0.037	0.003-0.037	0.026
TDE					
Average	0.013	0.015	0.006	0.005	0.007
Positive Composites					
Number	4	2	6	3	4
Range	0.017-0.024	T-0.087	T-0.013	0.010-0.027	T-0.018
DIELDRIN					
Average	0.002	0.003	0.003	0.001	0.002
Positive Composites					
Number	2	5	4	4	3
Range	T-0.010	T-0.006	T-0.006	T-0.003	0.001-0.006
CADMIUM					
Average	0.01	0.01	0.01	0.02	0.02
Positive Composites					
Number	5	4	6	6	5
Range	0.01	0.01-0.02	0.01-0.04	0.01-0.02	0.01-0.05
BHC					
Average	0.002	T	T	T	0.001
Positive Composites					
Number	2	1	2	1	1
Range	0.007-0.009	0.002	T-0.003	T	0.007
IX. Fruits [1]					
Residues, ppm					
ETHION					
Average	0.005	0.004	0.028	0.004	0.017
Positive Composites					
Number	2	2	5	3	3
Range	0.009-0.02	0.007-0.018	0.008-0.073	T-0.015	0.099
KELTHANE					
Average	0.001	0.007	0.014	0.015	0.003
Positive Composites					
Number	1	2	3	4	1
Range	0.007	0.005-0.035	0.015-0.039	T-0.066	0.019
DDT					
Average	0	T	0	T	T
Positive Composites					
Number	0	1	0	3	2
Range	—	T	—	T-0.003	T-0.002
X. Oils, Fats, and Shortening [1]					
Residues, ppm					
DIELDRIN					
Average	0.001	0.001	T	0.001	T
Positive Composites					
Number	5	6	4	2	2
Range	T-0.003	T-0.006	T	T-0.005	T
DDE					
Average	0.002	0.002	0.001	0.001	0.002
Positive Composites					
Number	4	5	4	4	4
Range	T-0.005	T-0.006	T-0.003	T-0.008	T-0.008
DDT					
Average	0.001	0.003	0.001	0.001	T
Positive Composites					
Number	4	5	3	4	2
Range	T-0.005	T-0.012	T-0.006	T-0.007	T
MALATHION					
Average	0.024	0.008	0.006	0.007	0.004
Positive Composites					
Number	3	3	2	2	2
Range	0.022-0.097	0.010-0.021	0.009-0.030	0.014-0.029	0.009-0.017
CADMIUM					
Average	0.01	0.01	0.02	0.02	0.03
Positive Composites					
Number	5	4	6	6	6
Range	0.01-0.02	0.01-0.03	0.01-0.03	0.01-0.03	0.02-0.04

(Continued next page)

TABLE 2A (cont'd). *Levels of pesticide residues commonly found—by food class and region, June 1970-April 1971*

Chemical	Baltimore	Boston	Kansas City	Los Angeles	Minneapolis
XI. Sugars and Adjuncts [1] Residues, ppm					
DDT					
Average	0	0.001	T	0.003	T
Positive Composites					
Number	0	4	1	1	3
Range	——	T-0.004	T	0.017	T-0.003
DDE					
Average	0	T	0	T	T
Positive Composites					
Number	0	3	0	3	2
Range	——	T	——	T-0.002	T-0.001
LINDANE					
Average	0	T	T	0.001	0.001
Positive Composites					
Number	0	2	1	2	3
Range	——	T	0.002	0.002	T-0.004
CADMIUM					
Average	0.01	0.01	0.01	0.01	0.01
Positive Composites					
Number	2	3	3	3	3
Range	0.02	0.01-0.03	0.01-0.02	0.01-0.02	0.01
XII. Beverages [1] Residues, ppm					
BROMIDES					
Average	0.92	——	0.25	0.33	0.33
Positive Composites					
Number	2	0	1	1	1
Range	2.5-3.0	——	1.5	2.0	2.0

NOTE: —— denotes not applicable.
T = Trace: see definition under Analytical Methods.

[1] Six composite samples examined from each of five districts: Baltimore, Boston, Kansas City, Los Angeles, and Minneapolis. Residues listed are averages of the six composites from each site.

TABLE 2B. *Pesticides found infrequently—by food class and region, June 1970-April 1971*

Pesticide	District	No. Composites	Amount
I. Dairy Products [1] Residues, ppm			
HCB	Boston	1	T
	Kansas City	1	T
	Los Angeles	2	0.001, T
Lindane	Kansas City	2	T, T
TDE	Baltimore	1	T
	Boston	2	T, 0.001
	Kansas City	3	T, T, 0.001
	Los Angeles	2	T, 0.001
	Minneapolis	1	T
Cadmium	Baltimore	1	0.01
	Boston	1	0.06
	Los Angeles	1	0.01
	Minneapolis	1	0.02
HCB	Boston	1	T
	Kansas City	1	T
	Los Angeles	2	T, 0.001
Methoxychlor	Kansas City	2	T, 0.008
	Minneapolis	1	0.006
PCP	Kansas City	1	T
Bromides	Baltimore	2	5.0, 5.0
	Boston	1	1.5
	Kansas City	1	4.0
	Los Angeles	2	2.0, 5.5
	Minneapolis	1	3.0
II. Meat, Fish, and Poultry [1] Residues, ppm			
Lindane	Boston	1	T
	Kansas City	3	T, T, 0.001
	Los Angeles	1	0.001
	Minneapolis	3	T, T, 0.001
BHC	Boston	3	T, T, T
	Kansas City	2	T, 0.001
	Los Angeles	2	T, T
HCB	Los Angeles	1	T
Bromides	Baltimore	2	7.5, 8.0
	Boston	2	3.5, 4.5
	Los Angeles	2	2.0, 6.5
	Minneapolis	1	5.5

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TABLE 2B (cont'd). *Pesticides found infrequently—by food class and region, June 1970-April 1971*

Pesticide	District	No. Composites	Amount
	III. Grain and Cereal [1] Residues, ppm		
Heptachlor Epoxide	Boston	2	T, T
Carbaryl	Boston	2	T, T
	Los Angeles	1	T
BHC	Kansas City	1	T
	Los Angeles	2	T, 0.007
TDE	Baltimore	1	T
	Boston	1	T
	Minneapolis	3	T, 0.001, 0.001
Ronnel	Kansas City	1	0.007
o-Phenylphenol	Los Angeles	1	T
Methoxychlor	Minneapolis	1	T
	IV. Potatoes [1] Residues, ppm		
Botran	Baltimore	1	0.003
Endrin	Boston	1	T
	Los Angeles	1	0.007
CIPC	Los Angeles	1	0.14
TDE	Boston	1	T
Carbaryl	Boston	1	T
	Kansas City	1	T
Endosulfan	Boston	1	0.007
	Los Angeles	1	T
Bromides	Baltimore	2	16.0, 13.0
	Boston	2	1.0, 1.0
	Minneapolis	2	4.0, 2.0
Arsenic	Minneapolis	1	0.1
BHC	Boston	1	0.002
	V. Leafy Vegetables [1] Residues, ppm		
Dieldrin	Boston	3	T, T, 0.001
	Minneapolis	2	0.001, 0.005
Carbaryl	Boston	1	T
2,4-D	Baltimore	1	0.01
	Minneapolis	2	0.02, 0.13
Methyl Parathion	Baltimore	1	T
	Boston	1	T
	Los Angeles	1	0.011
Diazinon	Baltimore	1	T
	Boston	1	0.004
	Los Angeles	1	0.003
	Minneapolis	1	0.020
Bromides	Baltimore	2	4.0, 4.0
	Boston	2	0.5, 1.0
	Kansas City	2	51.0, 3.0
	Los Angeles	1	2.5
	Minneapolis	2	2.5, 1.5
HCB	Boston	1	T
TDE	Boston	2	T, 0.002
	Minneapolis	1	0.001
Dacthal	Boston	1	T
Malathion	Kansas City	1	T
	VI. Legume Vegetables [1] Residues, ppm		
BHC	Boston	1	T
Dieldrin	Minneapolis	1	T
TDE	Baltimore	1	T
	Boston	2	T, T
	Los Angeles	3	T, 0.001, 0.003
	Minneapolis	1	0.001
Carbaryl	Los Angeles	1	T
Parathion	Kansas City	1	T
Bromides	Baltimore	2	2.0, 4.0
	Boston	2	1.5, 1.5
	Kansas City	1	5.5
	Minneapolis	1	2.0

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TABLE 2B (cont'd). *Pesticides found infrequently—by food class and region, June 1970-April 1971*

Pesticide	District	No. Composites	Amount
	VII. Root Vegetables [1] Residues, ppm		
Dieldrin	Boston	1	0.005
	Minneapolis	1	0.001
o-Phenylphenol	Baltimore	2	T, T
TDE	Baltimore	2	0.007, 0.011
Lindane	Boston	1	0.008
	Los Angeles	1	0.023
Toxaphene	Los Angeles	1	T
Carbaryl	Los Angeles	2	T, 0.006
Bromides	Baltimore	2	5.0, 3.5
	Boston	2	0.5, 6.0
	Kansas City	1	1.5
	Los Angeles	1	4.0
	Minneapolis	1	4.0
	VIII. Garden Fruits [1] Residues, ppm		
Parathion	Baltimore	2	T, 0.004
	Minneapolis	1	0.005
Carbaryl	Boston	2	T, 0.5
	Los Angeles	1	T
Endosulfan	Boston	1	0.061
	Los Angeles	1	T
o-Phenylphenol	Baltimore	1	T
Lindane	Kansas City	1	0.002
	Los Angeles	1	T
	Minneapolis	1	0.003
Kelthane	Kansas City	1	0.019
DDE	Baltimore	1	0.007
	Kansas City	2	T, 0.003
	Los Angeles	2	0.001, 0.002
Bromides	Baltimore	2	4.5, 6.0
	Boston	1	3.5
	Kansas City	1	0.5
	Los Angeles	2	3.0, 3.5
	Minneapolis	1	5.0
	IX. Fruits [1] Residues, ppm		
Carbaryl	Baltimore	1	0.15
	Boston	3	T, T, 0.005
	Los Angeles	3	T, T, T
	Minneapolis	1	0.006
Perthane	Boston	4	T, T, 0.022, 0.009
	Los Angeles	1	0.018
Botran	Minneapolis	1	0.006
o-Phenylphenol	Kansas City	1	0.1
	Los Angeles	3	T, T, 0.2
	Minneapolis	3	T, 0.1, 0.25
Phosalone	Boston	1	0.278
TDE	Boston	1	T
	Kansas City	1	0.004
	Los Angeles	1	T
	Minneapolis	1	0.009
Endosulfan	Boston	1	0.011
	Los Angeles	1	T
	Minneapolis	3	T, 0.001, 0.045
Lindane	Los Angeles	1	0.003
Diazinon	Kansas City	1	0.009
Arsenic	Baltimore	1	0.1
	Boston	1	0.1
Cadmium	Baltimore	1	0.01
	Boston	1	0.01
	Kansas City	1	0.03
	Los Angeles	1	0.01
Bromides	Baltimore	2	5.5, 6.0
	Boston	2	0.5, 1.5
	Los Angeles	1	1.5
	Minneapolis	1	6.5
DDE	Boston	2	T, T
	Kansas City	2	T, T
	Los Angeles	2	0.001, 0.002
	Minneapolis	3	0.001, 0.001, T
Dieldrin	Boston	1	0.002
	Los Angeles	1	T
Malathion	Kansas City	1	0.036
	Los Angeles	3	0.039, 0.026, 0.089
	Minneapolis	3	0.021, 0.003, 0.062

(Continued next page)

TABLE 2B (cont'd). *Pesticides found infrequently—by food class and region, June 1970-April 1971*

Pesticide	District	No. Composites	Amount
	X. Oils, Fats, and Shortening [1] Residues, ppm		
Diazinon	Baltimore	1	T
TDE	Baltimore	3	T, T, 0.013
	Boston	2	0.011, 0.009
	Kansas City	3	T, T, T
	Los Angeles	4	T, T, T, 0.007
	Minneapolis	2	T, T
Bromides	Baltimore	2	12.0, 12.0
	Boston	2	2.5, 5.5
	Minneapolis	1	12.0
	XI. Sugars and Adjuncts [1] Residues, ppm		
TDE	Boston	3	T, T, 0.002
	Los Angeles	1	T
	Minneapolis	2	T, 0.001
Heptachlor Epoxide	Boston	1	T
	Minneapolis	1	T
BHC	Boston	2	0.002, 0.002
	Los Angeles	2	T, T
	Minneapolis	2	T, 0.001
Malathion	Los Angeles	1	0.016
Arsenic	Baltimore	1	0.3
Bromides	Baltimore	2	5.5, 6.0
	Boston	2	7.5, 9.5
	Kansas City	2	0.5, 3.5
	Los Angeles	1	23.0
	Minneapolis	1	12.0
PCP	Kansas City	1	0.011
Diazinon	Minneapolis	1	T
	XII. Beverages [1] Residues, ppm		
DDT	Boston	1	T
TDE	Boston	1	T
Lindane	Los Angeles	1	T
Cadmium	Baltimore	1	0.01
	Kansas City	1	0.01
	Los Angeles	1	0.01

NOTE: T = Trace: see definition under Analytical Methods

[1] Six composite samples examined from each of five districts: Baltimore, Boston, Kansas City, Los Angeles, and Minneapolis.

TABLE 3. *Recovery experiments on pesticides found in total diet samples, June 1970-April 1971*

Pesticide	Type of Food Composite	Spike Level, ppm	Blank Level,[1] ppm Range	Total Found,[1] ppm Range	Number of Recovery Experiments
HEPTACHLOR EPOXIDE	Fatty	0.005	0-0.006 (0.003)	0.008-0.010 (0.009)	2
	Fatty	0.100	0	0.097	
	Nonfatty	0.005	0	0-0.008 (0.005)	9
p,p'-DDT	Fatty	0.050	0-0.037 (0.016)	0.051-0.072 (0.059)	3
	Nonfatty	0.010	0.002-0.003 (0.003)	0.010-0.012 (0.011)	3
RONNEL	Fatty	0.01	0	0.008-0.010 (0.009)	2
	Nonfatty	0.01	0	0.008-0.011 (0.010)	3
	Nonfatty	0.075	0	0.061-0.078 (0.068)	6
TDE	Fatty	0.01	0-0.007 (0.003)	0.004-0.016 (0.010)	2
	Nonfatty	0.01	0	0.011-0.013 (0.012)	3
DIELDRIN	Fatty	0.010	0.002-0.010 (0.006)	0.010-0.020 (0.015)	2
	Nonfatty	0.050	0	0.049	1
	Nonfatty	0.005	0-0.008 (0.002)	0.003-0.012 (0.006)	5
ENDRIN	Fatty	0.300	0	0.237	1
	Fatty	0.010	0	0.008-0.010	3
	Nonfatty	0.010	0	0.006-0.014 (0.011)	7

(Continued next page)

TABLE 3 (cont'd). *Recovery experiments on pesticides found in total diet samples, June 1970-April 1971*

Pesticide	Type of Food Composite	Spike Level, ppm	Blank Level,[1] ppm Range	Total Found,[1] ppm Range	Number of Recovery Experiments
BHC	Fatty	0.005	0-0.002 (0.001)	0.003-0.007 (0.005)	6
	Nonfatty	0.003	0-0.001 (0)	0.003-0.004 (0.003)	14
ALDRIN	Fatty	0.003	0	0.002-0.003 (0.003)	2
	Nonfatty	0.050	0	0.041-0.043 (0.042)	2
	Nonfatty	0.005	0	0.004-0.007 (0.006)	4
DDE	Nonfatty	0.005	0	0.003-0.008 (0.004)	6
	Fatty	0.005	0.002-0.006 (0.004)	0.008-0.010 (0.009)	3
	Nonfatty	0.10	0	0.111-0.117 (0.114)	2
	Fatty	0.20	0.014	0.193	1
CHLORDANE	Fatty	0.1	0	0.088	1
	Nonfatty	0.1	0	0.079-0.089 (0.084)	2
	Fatty	0.2	0	0.016-0.158 (0.087)	2
	Nonfatty	0.2	0	0.174-0.207 (0.186)	4
METHOXYCHLOR	Fatty	0.1	0	0.091-0.099 (0.095)	2
	Nonfatty	0.1	0	0.072-0.103 (0.086)	4
HEPTACHLOR	Fatty	0.003	0	0.001-0.002 (0.002)	3
	Nonfatty	0.003	0	0.001-0.002 (0.002)	6
PCB'S	Fatty	0.075	0-0.017 (0.008)	0.052-0.059 (0.056)	2
	Nonfatty	0.075	0	0.048-0.072 (0.056)	4
TOXAPHENE	Fatty	0.200	0	0.189-0.203 (0.196)	2
	Nonfatty	0.200	0	0.174-0.212 (0.191)	3
MERCURY	Fatty	0.10	0	0.094-0.130 (0.103)	4
	Fatty	0.02	0-0.024 (0.004)	0.008-0.042 (0.020)	16
	Nonfatty	0.1	0	0.095-0.100 (0.098)	5
	Nonfatty	0.02	0-0.008 (0.001)	0.013-0.034 (0.021)	32
CADMIUM	Fatty	0.1	0-0.030 (0.013)	0.086-0.250 (0.123)	8
	Fatty	0.04	0-0.020 (0.004)	0.024-0.069 (0.036)	20
	Nonfatty	0.10	0-0.051 (0.017)	0.092-0.151 (0.116)	6
	Nonfatty	0.04	0-0.053 (0.007)	0.018-0.192 (0.047)	42
ARSENIC	Fatty	0.5	0-0.125 (0.017)	0.160-0.576 (0.439)	10
	Fatty	0.1	0-0.100 (0.005)	0.030-0.290 (0.116)	21
	Nonfatty	0.5	0-0.03 (0.003)	0.110-0.720 (0.412)	22
	Nonfatty	0.15	0	0.030-0.246 (0.127)	37
	Nonfatty	1.00	0-0.060 (0.005)	0.20-1.05 (0.701)	11
CARBARYL	Nonfatty	1.0	0	0.10-1.79 (0.98)	8
	Nonfatty	0.5	0	0.20-0.50 (0.48)	14
	Nonfatty	0.20	0	0.05-0.30 (0.18)	38
o-PHENYLPHENOL	Nonfatty	0.5	0	0.25-0.50 (0.33)	10
	Nonfatty	0.2	0	0-0.20 (0.15)	16

(Continued next page)

TABLE 3 (cont'd). *Recovery experiments on pesticides found in total diet samples, June 1970-April 1971*

Pesticide	Type of Food Composite	Spike Level, ppm	Blank Level,[1] ppm Range	Total Found,[1] ppm Range	Number of Recovery Experiments
PARATHION	Fatty	0.02	0	0.010-0.017 (0.014)	4
	Nonfatty	0.02	0	0.017-0.026 (0.021)	8
	Nonfatty	0.10	0-0.020 (0.003)	0.060-0.120 (0.095)	6
MALATHION	Fatty	0.02	0-0.007 (0.002)	0.016-0.030 (0.022)	4
	Nonfatty	0.02	0-0.016 (0.002)	0.013-0.037 (0.021)	8
	Nonfatty	0.10	0-0.038 (0.007)	0.083-0.128 (0.101)	5
DIAZINON	Nonfatty	0.01	0	0.008-0.012 (0.010)	6
	Fatty	0.05	0	0.040-0.064 (0.048)	4
2,4-D	Fatty	0.05	0	0.006-0.040 (0.021)	7
	Nonfatty	0.03	0	0.005-0.037 (0.021)	11
2,4-DB	Fatty	0.03	0	0.004-0.036 (0.021)	8
	Nonfatty	0.03	0	0.009-0.037 (0.027)	16
2,4,5-TP	Fatty	0.20	0	0.032-0.074 (0.059)	3
	Fatty	0.02	0	0-0.016 (0.009)	6
	Nonfatty	0.03	0	0.009-0.027 (0.022)	12

[1] Numbers in parentheses represent average residue levels.

GENERAL

Residue Accumulation in Selected Vertebrates Following a Single Aerial Application of Mirex Bait, Louisiana—1971-72 [1]

H. L. Collins,[2] G. P. Markin,[3] and John Davis [1]

ABSTRACT

A survey to monitor accumulation of mirex residues in 61 species of vertebrates and certain components of the human food chain was conducted in Louisiana from May 1971 to May 1972 following a single application of mirex bait. All gas-liquid chromatographic analyses were performed on composited, whole-body homogenates. Levels of residues detected ranged from less than 0.001 to 8.483 ppm.

Highest concentrations of mirex were detected in loggerhead shrikes and mockingbirds 3 months after treatment. Although mirex was detected in 89 percent of the total samples analyzed, residues noted were usually less than 1 ppm.

Introduction

Because of increased interest in environmental effects of chlorinated pesticides, as well as increasingly refined and exacting analytical techniques, numerous papers and unpublished reports on the accumulation of mirex residues in nontarget organisms have appeared in recent years *(1-5)*. Most of these studies have dealt with residues following multiple applications of mirex bait employed in attempts to eradicate or suppress isolated imported fire ant infestations. Other papers have reported on residues following massive doses of mirex administered to test animals in the laboratory *(6-9)*.

The majority of treated acreage now receives a single mirex application (1¼ lb bait or 1.7 g actual toxicant/acre) in State and Federal control programs aimed at providing short-term relief for landowners *(10)*. A scarcity of information on residue levels to be expected from this type of program prompted the present study. The primary objective is to investigate and compare accumulation of mirex residues in selected vertebrates and certain components of the human food chain for 1 year following a single application of mirex bait. Vertebrates chosen represent certain families or orders whose members occupy the same general habitat, have similar food habits, and are available at all times of the year. Preliminary results of this study are reported in this paper.

DESCRIPTION OF STUDY AREA

The 2-square-mile study area was located in Washington Parish in the east central corner of Louisiana near the town of Bogalusa. Agricultural practices in the area are generally limited to dairy and timber farming. Permanent pastureland and hardwood bottom land predominate although hills are usually covered by stands of pine interspersed with hardwoods and underbrush. The topography is diversified enough to provide an abundance of food and cover for numerous species of vertebrates. This diversity and the fact that there had been no previous mirex treatments in the area provided the basis for its selection as a study site.

The area is drained by several small streams whose flow is often interrupted during dry periods. Pushepetapa Creek, a tributary of the Pearl River, flows through the center of the study area year-around. Researchers monitored two species of fish which inhabit this body of water. Numerous farm ponds averaging less than 1 acre in size are scattered over the area and usually contain sizable populations of warm-water fish such as bluegills, green sunfish, and mosquito fish. Eight of these ponds were chosen as study sites; all fish samples except for those from Pushepetapa Creek were taken in these ponds.

Methods and Materials

BAIT APPLICATION

The study area was treated with mirex bait by a Piper Pawnee aircraft on May 4 and 5, 1971. The plane was

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equipped with a Swathmaster granular spreader calibrated to deliver the present recommended dosage of 1.25 lb. standard 4X mirex bait per acre (1.7 g actual toxicant/acre). Ground personnel guided the aircraft with helium-filled Kytoons.

SAMPLING PROCEDURES

Terrestrial animals were collected by shooting or trapping. Havahart live traps baited with canned sardines and peanut butter were employed to capture opossums and rodents; armadillos, birds, and rabbits were shot. A .22-caliber pistol loaded with No. 12 dust shot was used to collect frogs, snakes, and lizards. Fish were collected by seining or trapping with a common fish trap constructed of 1-inch mesh poultry netting and baited with cottonseed meal. These collections, while seemingly incomplete in some instances, represent 1,120 person-hours of work. A complete phylogenetic listing of the vertebrates sampled is presented in Table 1. Scientific names and phylogenetic arrangements generally follow those given by Blair et al. *(11)*.

Only the central portion of the treated area was utilized for sampling. A buffer zone one-half to one-fourth mile wide was maintained to reduce migration of study animals in and out of the treated area. Some migration of the more mobile species did doubtless occur; however, the home range of most animals sampled was probably restricted to the test area.

Sampling was carried out in seven excursions at 1- to 3-month intervals from April 1971 until May 1972. Unfortunately, replication of samples and thus statistical interpretation of the data were not possible because of limitations of gas-liquid chromatography (GLC) time and personnel required to replicate sampling. All individuals of a given species were lumped together at

TABLE 1. *Phylogenetic listing of selected vertebrates sampled for mirex residues*

MAMMALIA
- RODENTIA
  - Cricetidae
    - *Reithrodontomys humulis* (Audubon & Bachman)—Eastern harvest mouse
- LAGOMORPHA
  - Leporidae
    - *Sylvilagus floridanus* (Allen)—Eastern cottontail
- MARSUPIALIA
  - Didelphidae
    - *Didelphis marsupialis* (Linnaeus)—Common opossum
- XENARTHRA
  - Dasypodidae
    - *Dasypus novemcinctus* (Linnaeus)—Nine-banded armadillo

AVES
- CICONIIFORMES
  - Ardeidae
    - *Egretta thula* (Molina)—Snowy egret
    - *Casmerodius albus* (Linnaeus)—Greater egret
    - *Hydranassa tricolor* (P. L. S. Muller)—Louisiana heron
    - *Butorides virescens* (Linnaeus)—Green heron
    - *Ardeola ibis* (Linnaeus)—Cattle egret
    - *Florida caerulea* (Linnaeus)—Little blue heron
- FALCONIFORMES
  - Accipitridae
    - *Accipiter cooperii* (Bonaparte)—Cooper's hawk
- GALLIFORMES
  - Phasianidae
    - *Colinus virginianus* (Linnaeus)—Bobwhite quail
    - *Gallus gallus* (Linnaeus)—Domestic chicken
- CHARADRIIFORMES
  - Charadriidae
    - *Charadrius vociferus* (Linnaeus)—Killdeer
- CUCULIFORMES
  - Cuculidae
    - *Coccyzus americanus* (Linnaeus)—Yellow-billed cuckoo
- PICIFORMES
  - Picidae
    - *Melanerpes carolinus* (Linnaeus)—Red-bellied woodpecker
    - *Melanerpes erythrocephalus* (Linnaeus)—Red-headed woodpecker
- PASSERIFORMES
  - Tyrannidae
    - *Tyrannus tyrannus* (Linnaeus)—Eastern kingbird
  - Corvidae
    - *Cyanocitta cristata* (Linnaeus)—Blue jay
  - Mimidae
    - *Mimus polyglottos* (Linnaeus)—Mockingbird
    - *Toxostoma rufum* (Linnaeus)—Brown thrasher
  - Turdidae
    - *Turdus migratorius* (Linnaeus)—American robin
  - Laniidae
    - *Lanius ludovicianus* (Linnaeus)—Loggerhead shrike
  - Icteridae
    - *Sturnella magna* (Linnaeus)—Eastern meadowlark
    - *Agelaius phoeniceus* (Linnaeus)—Red-winged blackbird
    - *Quiscalus quiscula* (Linnaeus)—Common grackle
    - *Molothrus ater* (Boddaert)—Brown-headed cowbird
  - Thraupidae
    - *Pyrrhuloxia cardinalis* (Linnaeus)—Cardinal

REPTILIA
- SQUAMATA
  - Colubridae
    - *Coluber constrictor constrictor* (Linnaeus)—Southern black racer
    - *Natrix rhombifera rhombifera* (Hallowell)—Diamond-backed water snake
    - *Natrix erythrogaster flavigaster* (Conant)—Yellow-bellied water snake
  - Iguanidae
    - *Anolis carolinensis* (Voigt)—Green anole
    - *Sceloporus undulatus* (Latreille)—Eastern fence lizard
  - Scincidae
    - *Lygosoma laterale* (Say)—Ground skink
    - *Eumeces fasciatus* (Linnaeus)—Five-lined skink
- CHELONIA
  - Kinosterninae
    - *Kinosternon subrubrum* (Lacépède)—Mud turtle
  - Emydinae
    - *Terrapene carolina* (Linnaeus)—Gulf Coast box turtle
  - Testudinidae
    - *Gopherus polyphemus* (Daudin)—Gopher tortoise

AMPHIBIA
- SALIENTA
  - Bufonidae
    - *Bufo terrestris* (Bonnaterre)—Southern toad
  - Microhylidae
    - *Gastrophryne carolinensis* (Holbrook)—Narrow-mouthed toad
  - Ranidae
    - *Rana catesbeiana* (Shaw)—Bullfrog
    - *Rana pipiens* (Schreber)—Leopard frog
- CAUDATA
  - Plethodontidae
    - *Plethodon glutinosus* (Green)—Slimy salamander

OSTEICHTHYES
- CYPRINIFORMES
  - Cyprinidae
    - *Notemigonus crysoleucas* (Mitchill)—Golden shiner
  - Ictaluridae
    - *Ictalurus nebulosus* (LeSueur)—Brown bullhead
  - Poeciliidae
    - *Gambusia affinis* (Baird & Girard)—Mosquitofish
  - Centrarchidae
    - *Micropterus salmoides* (Lacépède)—Largemouth bass
    - *Chaenobryttus coronarius* (Bartram)—Warmouth
    - *Lepomis cyanellus* (Rafinesque)—Green sunfish
    - *Lepomis megalotis* (Rafinesque)—Longear sunfish
    - *Lepomis macrochirus* (Rafinesque)—Bluegill

each collection date and the composite was analyzed. Thus each sample usually consisted of three or more individuals except for less accessible specimens such as certain birds, opossums, and armadillos (Table 2).

All samples were placed on ice immediately after capture and returned to the laboratory where they were kept frozen until GLC analysis could be performed.

SURVEY OF ITEMS IN HUMAN FOOD CHAIN

Several recent studies have dealt with mirex residues in the human food chain. Ford et al. *(12)* reported on mirex residues in beef fat samples collected from cattle raised on pastures which had been treated two or more times. Others have reported on mirex residues in seafood and catfish samples *(2,4,13)*.

Certain human food items such as milk, chicken eggs, various species of fish, and game birds and animals that are occasionally consumed by man were also monitored in the present study. Milk samples were taken from a dairy located within the treated area. Eggs and domestic chickens were obtained from a flock of poultry that ranged freely over their owner's farm.

METHOD OF ANALYSIS

Analytical techniques sensitive to 0.001 ppm as described by Markin et al. *(10)* were used to determine residues in all samples. Composited samples of blended whole-body tissues were processed by grinding a 5-g portion of the blended tissue homogenate with 5 g Na_2SO_4 in a mortar and pestle, added to 200 ml of 3:1 nanograde hexane and isopropanol, mixed for 1 hour on a concentric rotor, and placed in a separatory funnel. The solution was washed three times with 200 ml distilled water to remove the isopropanol. After separation, the hexane was cleaned in 11-by-500-mm chromatographic columns packed with 10 g florisil with a 2.5-cm Na_2SO_4 layer above and below the florisil. The hexane was concentrated to 15 ml in a three-ball Snyder column on an explosion-proof hotplate and stored in glass-stoppered conical test tubes. Further concentration was performed when necessary by heating the extract in a water bath with an airstream filtered through a Drierite filter. Portions of the final extract measuring 1 to 7.5 µl were injected into a twin-column Microtek gas chromatograph. Instrument parameters were:

Column:	(A) Glass, 1.24 m by 17 mm, packed with 3 percent DC-200 on Supelcoport 100-120 mesh. (B) Glass, 2.48 m by 17 mm, packed with a mixture of equal portions of separately coated 1.5 percent OV-17, and 1.95 percent QF-1.
Detector:	Electron capture using 130 MC tritium as the ionizing source.
Temperatures:	Injector 225°C. Columns 190°C. Detector 210°C.
Carrier Gases:	Purified nitrogen at 75 ml/min.

Recovery averaged 97 percent when fortified samples were processed and analyzed by this procedure. Results presented have not been corrected for percent recovery.

TABLE 2. *Mirex residues (ppm) in selected vertebrates from pretreatment to 1 year after single mirex application*

Biotic Group and Species	Pretreatment		2 Wk		1 Mo		3 Mo		6 Mo		9 Mo		12 Mo	
	No. Analy.	Residue Found	No. Analy.	Residue Found	No. Analy.	Residue Found	No. Analy.	Residue Found	No. Analy.	Residue Found	No. Analy.	Residue Found	No. Analy.	Residue Found
MAMMALS														
Eastern harvest mouse	2	0.013	3	0.310	1	0.450	2	0.049	2	0.014	4	0.003	1	0.010
Eastern cottontail	0	—	1	ND	1	ND	0	—	1	ND	1	0.254	0	—
Opossum	1	0.120	2	0.044	0	—	1	0.099	1	0.004	0	—	0	—
Armadillo	0	—	1	0.076	0	—	0	—	0	—	0	—	1	0.054
BIRDS														
Annual Residents														
Bobwhite quail	1	0.113	1	0.012	1	0.475	1	1.502	0	—	1	0.064	2	0.036
Cardinal	1	0.113	1	0.685	1	0.105	2	0.222	1	0.064	3	0.043	2	0.051
Mockingbird	1	0.030	1	1.579	2	3.627	1	4.549	3	0.807	2	1.936	1	0.282
Loggerhead shrike	1	0.346	1	0.706	0	—	1	8.483	2	0.754	2	3.560	1	3.666
Blue jay	1	0.007	2	0.027	2	0.035	2	0.113	2	0.181	2	0.071	1	0.198
Meadowlark	2	0.010	1	0.312	1	0.870	3	2.455	1	0.201	2	1.241	1	0.299
Killdeer	1	0.100	1	0.096	1	0.132	1	0.015	2	0.473	1	0.448	1	0.346
Brown thrasher	0	—	0	—	1	0.669	0	—	0	—	1	ND	1	0.624
Purple grackle	1	0.018	2	0.734	2	2.427	0	—	0	—	1	1.140	1	0.073
Eastern cowbird	1	0.015	0	—	1	0.713	0	—	3	0.088	3	0.028	1	0.012
Redwinged blackbird	0	—	0	—	1	0.072	1	0.280	0	—	1	0.084	2	0.208
Red-headed woodpecker	1	0.006	2	1.826	0	—	1	0.088	0	—	0	—	1	0.061
Red-bellied woodpecker	0	—	1	0.015	0	—	0	—	2	0.070	2	0.035	0	—
Summer Residents														
Cattle egret	2	0.514	1	0.085	1	0.090	3	0.163	0	—	0	—	1	0.221
Eastern kingbird	1	0.018	1	0.121	0	—	0	—	0	—	0	—	2	0.065
Yellow-billed cuckoo	0	—	1	0.042	0	—	1	0.023	0	—	0	—	0	—
Green heron	0	—	1	0.001	1	0.409	1	0.260	0	—	0	—	1	0.082
Winter Residents														
American robin	0	—	0	—	0	—	0	—	1	0.021	2	0.054	0	—
Transients														
Little blue heron	0	—	0	—	1	0.101	0	—	0	—	0	—	0	—
Cooper's hawk	0	—	0	—	1	0.087	0	—	0	—	0	—	0	—
Snowy egret	0	—	0	—	0	—	1	0.054	0	—	0	—	0	—
Louisiana heron	0	—	0	—	0	—	1	0.005	0	—	0	—	0	—
Greater egret	0	—	0	—	0	—	1	0.096	0	—	0	—	0	—

(Continued next page)

TABLE 2 (cont'd). *Mirex residues (ppm) in selected vertebrates from pretreatment to 1 year after single mirex application*

	Pretreatment		2 Wk		1 Mo		3 Mo		6 Mo		9 Mo		12 Mo	
	No. of Analy.	Residue Found	No. of Analy.	Residue Found	No. of Analy.	Residue Found	No. of Analy.	Residue Found	No. of Analy.	Residue Found	No. of Analy.	Residue Found	No. of Analy.	Residue Found
REPTILES														
Aquatic														
Diamondback water snake	2	0.005	1	ND	1	0.029	0	—	0	—	3	0.037	1	0.054
Yellow-bellied water snake	0	—	1	0.002	0	—	0	—	1	0.078	0	—	0	—
Mud turtle	0	—	1	0.015	0	—	1	0.013	0	—	2	0.273	0	—
Terrestrial														
Gofer tortoise	1	0.001	0	—	1	ND	1	0.002	0	—	0	—	1	ND
Gulf coast box turtle	2	ND	2	ND	1	0.009	0	—	0	—	0	—	0	—
Southern black racer	1	ND	1	0.002	0	—	2	0.053	0	—	0	—	2	0.111
Southern fence lizard	0	—	1	0.003	2	0.065	5	0.191	0	—	3	0.040	2	0.025
Ground skink	2	ND	0	—	0	—	4	0.032	2	0.091	4	0.037	3	0.042
Five-lined skink	0	—	0	—	1	0.658	2	0.076	0	—	2	0.126	2	0.216
Green anole	2	ND	1	0.011	1	0.183	0	—	3	0.072	4	0.019	3	0.017
AMPHIBIANS														
Slimy salamander	1	ND	1	ND	2	0.097	4	0.828	0	—	2	0.254	2	0.020
Southern toad	2	ND	2	0.001	26	0.144	3	0.030	0	—	3	0.026	8	0.008
Leopard frog	0	—	4	0.002	1	0.015	0	—	0	—	0	—	0	—
Bullfrog	0	—	1	ND	0	—	0	—	0	—	1	0.001	0	—
Eastern narrow-mouthed toad	0	—	2	0.044	0	—	0	—	0	—	0	—	1	0.074
Tadpoles (undetermined species)	3	0.016	4	0.005	0	—	43	0.024	0	—	0	—	0	—
FISH														
Lentic Habitat														
Largemouth bass	1	ND	1	0.018	1	0.032	1	0.624	0	—	0	—	0	—
Warmouth	4	ND	0	—	0	—	1	0.009	9	0.005	2	0.005	8	0.012
Bluegill	23	0.002	15	0.012	23	0.019	79	0.025	29	0.013	36	0.009	10	0.026
Green sunfish	22	0.003	5	0.003	30	0.014	71	0.014	47	0.007	36	0.002	43	0.005
Longear sunfish	1	ND	0	—	4	0.016	4	0.039	1	0.016	0	—	0	—
Golden shiner	22	0.001	19	0.005	21	0.024	87	0.027	45	0.007	38	0.008	38	0.009
Mosquitofish	51	0.003	21	0.109	109	0.131	136	0.010	144	0.015	347	0.008	51	0.006
Brown bullhead	5	0.001	6	0.004	20	0.113	4	0.086	7	0.007	4	0.003	10	0.010
Lotic Habitat														
Bluegill	5	0.004	0	—	2	ND	2	0.057	5	0.006	0	—	5	0.011
Longear sunfish	5	0.002	4	0.003	0	—	3	0.007	2	0.007	4	0.021	2	0.006

NOTE: ND = no detectable residues; — = not sampled.

Results and Discussion

MIREX IN SELECTED VERTEBRATES

Mirex residues in selected vertebrates are shown in Table 2. With few exceptions these levels were quite low (0.001-0.005 ppm) although certain birds did accumulate residues in the range of 1 to 8 ppm. Of particular interest are the relatively high levels detected in loggerhead shrikes and mockingbirds. Authors assume that the residues reflect the diet of these birds. It is interesting to note that green herons did not accumulate high levels of residues as expected by virtue of their position in the aquatic food web. The extensive home range of the herons could account for their relatively low residue levels because it is possible that they derived the majority of their food outside the treated area. In general, birds such as cardinals, Eastern cowbirds, and quail, whose diets consisted primarily of seeds, fruits, and other vegetable matter, had lower levels than did the more carnivorous species such as shrikes, mockingbirds, and meadowlarks.

Of the four mammal species sampled, Eastern harvest mice contained the largest amount of residues: 0.450 ppm 1 month after treatment.

Reptiles and amphibians generally accumulated lower residues (0.001-0.828 ppm) than did birds and mammals (0.001-8.483 ppm). Surprisingly, carnivorous reptiles such as water snakes, lizards, and skinks did not appear to concentrate mirex as did birds with similar feeding habits. This may be related to the greater volume of food consumed by birds as opposed to reptiles. Birds usually consume more food per unit weight in any given time and may thus encounter and concentrate greater residues.

As expected, predatory species of fish such as largemouth bass contained more residues than did omnivorous species such as brown bullheads and sunfish. In general, residues detected in fish agreed fairly closely with those reported in an earlier study by Collins et al. *(14)*

An overview of various vertebrate trophic levels reveals that strict herbivorous species such as Eastern cottontails and gopher tortoises contained significantly less mirex than did either omnivorous or carnivorous species (Fig. 1). Regardless of trophic levels, however, residues in most animals peaked 1 to 3 months after treatment and decreased afterward.

ITEMS IN HUMAN FOOD CHAIN

Results of the survey of items in the human food chain are shown in Table 3. Mirex was detected in 77 per-

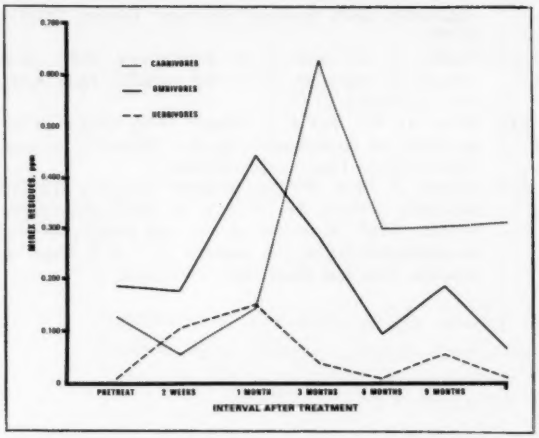

FIGURE 1. *Residue fluctuations in various vertebrate trophic levels following a single application of mirex bait*

cent of the samples analyzed. Detectable residues were still present in most samples 1 year after treatment. Highest concentrations found were in bobwhite quail (0.012-1.502 ppm) and largemouth bass (0.018-0.624 ppm). Mirex was not detected in beef fat prior to or 1 year after treatment. Low levels were found in milk (0.001-0.022 ppm), chicken eggs (0.001-0.493 ppm), and chickens (0.004-0.515 ppm). These results are in general agreement with those reported by Baetcke et al *(5)*. Their results indicated that mirex residues in milk ranged from 0.007 to 0.016 ppm; beef fat contained 0.012 to 0.042 ppm; chicken adipose tissue contained 0.087 ppm; and residues in quail ranged from 0.016 to 3.148 ppm.

This and other studies have demonstrated conclusively that low levels of mirex residues remain in the environment and are concentrated by some species *(4,5,10,13)*. All residue levels reported here are well below the level reported by others as causing acute toxicity to test animals such as rats, mice, birds, and fish *(7,9,15-17)*. However, there is virtually no information available on the long-range effects of low, chronic dosages on nontarget organisms.

Future research in the area of mirex residues should not merely monitor residues; research has already shown that they exist in virtually all components of the ecosystem. Instead, future research should attempt to divulge whether these residues are harmful, and if so, to which organisms.

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TABLE 3. *Mirex residues (ppm) in human food chain from pretreatment to 1 year after single mirex application*

Food Item	Pretreatment		2 Wk		1 Mo		3 Mo		6 Mo		9 Mo		12 Mo	
	Sample Size	Residue Found	Sample Size	Residue Found	Sample Size	Residue Found	Sample Size	Residue Found	Sample Size	Residue Found	Sample Size	Residue Found	Sample Size	Residue Found
Milk	1 qt	0.015	1 qt	ND	1 qt	0.022	1 qt	0.001	1 qt	ND	1 qt	ND	1 qt	ND
Chicken Eggs	12	ND	12	0.493	12	0.005	12	0.007	12	ND	12	0.011	12	0.001
Domestic Chickens	2	—	2	0.004	2	0.036	2	0.515	2	0.010	2	0.201	2	0.014
Beef Fat	1 lb	ND	0	—	0	—	0	—	0	—	0	—	1 lb	ND
Fish[1]														
Bluegills	28	0.003	15	0.012	25	0.019	79	0.041	34	0.009	36	0.009	15	0.018
Brown bullheads	5	0.001	6	0.004	20	0.113	4	0.086	7	0.007	4	0.003	10	0.010
Largemouth bass	1	ND	1	0.018	1	0.032	1	0.624	0	—	0	—	0	—
Game Animals and Birds														
Eastern cottontails	0	—	1	ND	1	ND	0	—	1	ND	1	0.254	0	—
Opossums	1	0.120	2	0.044	0	—	1	0.099	1	0.004	0	—	0	—
Bobwhite quail	1	0.113	1	0.012	1	0.475	1	1.502	0	—	1	0.064	2	0.036

NOTE: ND = no detectable residues; — = not sampled.
[1] Average of all samples collected from entire study area at indicated sampling interval.

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Residues of the Insecticide Mirex in Terrestrial and Aquatic Invertebrates Following a Single Aerial Application of Mirex Bait, Louisiana—1971-72[1]

G. P. Markin,[2] H. L. Collins,[3] and J. Davis [4]

ABSTRACT

Samples of 25 invertebrates were collected for 1 year following a broadcast application of mirex bait to 1,000 hectares of land in southeastern Louisiana for control of the imported fire ant. Immediately following the treatment, residues of 5.504 to 22.153 ppm were found in scavengers such as the imported fire ant which fed directly upon the bait. Predatory invertebrates accumulated residues more slowly; a maximum level of 10.010 ppm was found in spiders 10 weeks after the treatment. Herbivorous invertebrates usually did not accumulate significant amounts of mirex. Residue levels in all terrestrial and aquatic invertebrates decreased greatly during the following year; no detectable residues were found in 68 percent of the samples at the end of the study.

Introduction

In 1971 an extensive monitoring program for mirex was undertaken in southeastern Louisiana. The purpose of the study was to determine mirex residue levels in representative groups of animals and the physical environment, and the rate of accumulation or loss of residues over a 1-year period following a single treatment with bait for control of imported fire ants. A general description of the study and results of vertebrate monitoring have been presented by Collins et al. *(1)*; results of the study of residues in the physical environment were published by Spence et al. *(2)*. This paper presents data on mirex residues in invertebrate fauna.

Although some information exists on mirex residues in invertebrate populations, most of it is based on studies of animals collected from an area which received several closely spaced treatments with bait applied to determine the feasibility of eradicating the ant from isolated areas *(3,4)*. Samples were usually collected at one time and do not present any information on the rate of buildup or decline of residues in the overall population. Because mirex is annually applied to over 10 million acres *(4)* to control this ant, information pertaining to residues following such routine single-application control programs is more valuable in understanding the overall residue picture for this pesticide than are data primarily concerning experimental eradication programs. The present study was designed specifically to observe the residue picture following the normal practice of using a single application of bait to control this ant.

Sampling

The treated area was a 1,000-hectare (ha.) block of pasture and forest land in Washington Parish, La. A blanket treatment of 2.5 kg/ha. mirex 4X bait was applied to the total area May 4 and 5, 1971. The study area and method of bait application were reported by Collins et al. *(1)*. Researchers chose 25 groups of invertebrates to represent the general invertebrate fauna of the area and collected them prior to treatment and at various intervals over the following year. Initially, it was hoped that individual species could be used as indicators, but this was impractical because the brief life cycle and short season of occurrence of most invertebrates made it impossible to obtain most species during the entire year. It was then decided to concentrate on particular families or orders of invertebrates, the members of which occupied the same general habitat, had similar food habits, and were available at all times of the year.

Aquatic samples were collected from two small farm ponds approximately one-tenth ha. in size, lying in open improved pasture, and from a 100-m section of a

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small permanent stream (flow rate: 10 to 1,000-plus liters/min) just above its junction with Pushepetapa Creek. The drainage system of all three bodies of water lay entirely within the treated area. From each location, bottom organisms were collected by taking 10 bottom samples in 10 to 25 cm of water. Each sample consisted of the bottom sediment from an area one-tenth m^2 and 5 cm deep. It was washed through a 20-mesh screen and the desired organisms were collected. Free-swimming organisms were collected with a hand-held sweep net.

Soil insects were collected at three study sites 1 to 3 ha. in size scattered throughout the treatment area. At each site 10 soil samples, each representing an area one-tenth m^2, were randomly selected; the vegetation was removed by clipping and the upper layer of duff was scraped off. Soil was excavated to a depth of 10 cm, placed on a plastic sheet, and sorted by hand to retrieve the desired animals. Surface-living arthropods were collected from the same three sites by 30 pitfall traps. Pitfall traps were plastic-lined paper cups 7.5 cm in diameter and 18 cm deep. The cup was buried with the lip level at the soil surface; each cup contained 5 cm 50 percent alcohol. Traps were left out for 24 hours and animals which had fallen into the trap were immediately strained from the alcohol upon collection. Immediate removal of the animals from the alcohol and use of a solution which was only 50 percent alcohol were necessary to prevent the loss of mirex residues to the alcohol *(4)*.

Miscellaneous animals such as web spiders, grasshoppers, and leaf hoppers were collected at the same three study sites by sweeping with a sweep net 40 cm in diameter.

Samples were restricted to the six study sites: three aquatic sites and the three terrestrial sites. Nests of mud dauber wasps (*Sceliphron* sp.) were collected from several old barns in the study area. The six sampling sites were all located well within the treated area. A 1-km buffer area was set up to minimize the chance of animal migration from the untreated area into the treated block.

At the time of collection, all samples were placed in glass vials which had been prewashed in hexane and checked by gas-liquid chromatography (GLC) for contamination; aluminum foil was used to line lids. The vials were placed on ice until they were brought to the laboratory; samples were washed in tap water, sorted, identified, weighed, and counted. Samples were deep-frozen in glass vials until processed. Collections from the three sampling sites were combined into a single composite sample for each of the 25 indicator organisms at each collection interval. Samples usually contained between 20 and 100 individuals and were usually over 1 g in weight. However, it was sometimes necessary to use smaller samples during the winter. The smallest sample used was one-tenth g but contained at least five individual animals.

Analytical Procedures

Analytical procedures were basically the same as those used by Collins et al. *(1)*, who collected vertebrates from the same treatment area. Frozen samples were ground whole with a mortar and pestle with 5 g Na_2SO_4, added to 200 ml nanograde hexane and isopropyl alcohol (3:1), mixed for 1 hour in a concentric rotor, and placed in a separatory funnel. Samples were washed three times with 200 ml distilled water to remove the isopropyl alcohol. After separation, the hexane was cleaned in an 11-by-500-mm chromatographic column packed with 10 g florisil (or silica gel for fish) with a 2.5-cm Na_2SO_4 layer above and below the florisil. The hexane was concentrated in a three-ball Snyder column on an explosion-proof hotplate to 15 ml and was stored in glass-stoppered, conical-based test tubes. Further concentration was performed when necessary by heating the hexane in a water bath with an airstream filtered through a Drierite filter. Technicians injected 1- to 7.5-µl portions of the final extract into a twin column Microtek 220 gas chromatograph. Instrument parameters were:

Column:	(A) Glass, 1.24 m by 17 mm, packed with 3 percent DC-200 on Supelcoport 100-120 mesh. (B) Glass, 2.48 m by 7 mm, packed with mixture of equal portions of separately coated 1.5 percent OV-17 and 1.95 percent QF-1 on 60-80 mesh Chromosorb.
Detector:	Electron capture using 130 MC Tritium as ionizing source.
Temperatures:	Injector 225°C. Columns 190°C. Detector 210°C.
Carrier Gases:	Purified nitrogen at 75 ml/min.

The level of sensitivity with 1 g or larger samples was 0.001 ppm. Sensitivity of 0.1 g samples was 0.01 ppm. Recovery using this procedure averaged 97 percent when fortified samples were run through the processing and analytical procedures. Results presented have not been corrected for percent recovery.

Polychlorinated biphenyls (PCB's) are the major contaminants which complicate analyses for mirex *(4)*. Particular effort was made to watch for the characteristic series of peaks which identify these contaminants. However, because no evidence of PCB contamination was found, no more extensive cleanup was undertaken. For a more detailed discussion of the problems of PCB's, the types of equipment, reagents, and confirmation procedures used, see Markin et al. *(4)*.

Results

Table 1 presents mirex residues found in 25 invertebrate groups before treatment and for 1 year afterward. Several pretreatment samples contained small residues of mirex, indicating that it had been used in or near the test

area before the study. However, the three aquatic and three terrestrial sites sampled were specifically known not to have a history of mirex treatment; this was one reason for their selection as sampling locations. It can be presumed then, that specimens containing residues must have migrated from adjacent fields or perhaps even from outside the treatment area. Because mirex is commonly used in Louisiana to control the fire ant, pretreatment residues were not unexpected. In general, it was felt that the small number of pretreatment samples which had mirex residues were too few to be significant in interpreting the overall results of this study.

Mirex residues were detected in all but one of the groups sampled, white fringed beetle larvae. Amounts found usually corresponded very closely to group feeding habits. General scavengers that would be attracted to oil, such as the imported fire ant, fed directly upon the bait and contained the highest mirex levels found immediately after the treatment. Predacious invertebrates received mirex indirectly through the food chain and therefore showed slow but progressive buildup for 20

TABLE 1. *Residue levels of mirex in 25 invertebrate groups sampled for 1 year following a single bait application for control of the imported fire ant*

Specimen	Pre-treatment	Mirex Residues, ppm									
		24 hr	1 wk	2 wk	4 wk	10 wk	3 mo	6 mo	8 mo	10 mo	1 yr
Aquatic											
Dragonfly Larvae											
Insecta: Odonata	Neg	0.003	0.005	0.005	0.011	0.013	Neg	Neg	Neg	Neg	Neg
Water Scorpion											
Insecta: Hemiptera: Nepidae	Neg	0.076	0.017	0.124	0.015	0.028	0.008	0.003	0.003	0.002	0.003
Water Boatmen											
Insecta: Hemiptera: Corixidae	Neg	—	1.003	0.146	—	Neg	Neg	0.016	Neg	—	Neg
Back Swimmers											
Insecta: Hemiptera: Notonectidae	Neg	5.504	—	0.141	0.011	—	—	—	—	Neg	0.022
Giant Water Bugs											
Insecta: Hemiptera: Belostomatidae	0.001	0.038	Neg	0.013	0.038	0.004	0.004	0.009	—	—	Neg
Predacious Diving Beetles											
Insecta: Coleoptera: Dytiscidae	0.018	Neg	0.033	—	0.073	—	—	—	—	0.009	Neg
Water Scavenger Beetles											
Insecta: Coleoptera: Hydrophilidae	Neg	0.043	0.015	0.018	Neg	0.005	0.011	Neg	Neg	Neg	Neg
Midge Larvae											
Insecta: Diptera: Chironomidae	Neg	0.003	0.007	0.003	0.188	Neg	Neg	Neg	Neg	Neg	Neg
Crayfish											
Crustacea: Decapoda: Astacidae	Neg	0.737	—	0.687	0.115	0.153	0.004	Neg	0.003	0.002	0.004
Leeches											
Hirudinea: Glossiphoniidae	Neg	—	0.152	0.003	0.004	0.006	0.011	0.007	—	—	Neg
Soil											
Earthworms											
Oligochaeta: Opisthopora: Lumbricidae	Neg	Neg	—	0.002	—	0.038	Neg	Neg	0.026	0.004	0.005
Centipede											
Myriapoda: Chilopoda	Neg	Neg	—	0.248	—	0.225	0.336	—	0.038	0.192	0.044
Millipedes											
Myriapoda: Diplopoda	Neg	Neg	—	Neg	—	0.006	Neg	—	0.076	Neg	Neg
White Grubs (June beetle larvae)											
Insecta: Coleoptera: Scarabaeidae	Neg	Neg	—	0.005	—	Neg	0.004	Neg	0.032	Neg	Neg
White Fringe Beetle Larvae											
Insecta: Coleoptera: Curculionoidea	Neg	Neg	—	Neg	—	—	—	—	Neg	Neg	Neg
Pitfall Traps											
Crickets											
Insecta: Orthoptera: Gryllidae	Neg	1.630	—	0.072	0.040	0.030	0.003	0.009	—	Neg	Neg
Darkling Beetles											
Insecta: Coleoptera: Tenebrionidae	Neg	Neg	—	0.079	0.109	0.242	0.071	0.031	—	0.163	0.008
Scarab Beetles											
Insecta: Coleoptera: Scarabaeidae	Neg	0.018	—	0.008	0.830	0.010	0.020	Neg	—	Neg	Neg
Imported Fire Ants											
Insecta: Hymenoptera: Formicidae	Neg	22.153	—	—	—	Neg	Neg	Neg	—	Neg	Neg
Wolf Spiders											
Arachnida: Araneida: Lycosidae	Neg	—	—	Neg	0.159	0.012	0.019	0.014	—	Neg	Neg
Sweep Net Samples											
Leafhoppers											
Insecta: Homoptera: Cicadellidae	Neg	Neg	—	Neg	0.030	Neg	—	0.018	—	—	Neg
Grasshoppers											
Insecta: Orthoptera: Acrididae	Neg	—	—	Neg	0.023	—	Neg	0.008	—	Neg	Neg
Wild Bees											
Insecta: Hymenoptera: Apidae	Neg	Neg	—	Neg	0.008	0.002	Neg	Neg	—	—	Neg
Crab and Web Spiders											
Arachnida: Araneida	Neg	0.211	—	0.535	1.890	10.010	0.708	0.069	—	0.205	0.092
Other											
Mud daubers											
Insecta: Hymenoptera: Sphecidae											
Adults	0.008	—	—	—	—	Neg	—	0.158	—	—	0.076
Larvae	Neg	—	—	—	—	0.524	—	0.126	—	—	0.020

NOTE: All samples were adults unless otherwise noted.
All analysis was performed on a wet, whole-body basis.
Neg = no mirex at level of detection; — = no sample collected.

to 90 days after treatment. Smallest residues were found in herbivorous animals. Most residues began to decline after 90 days and had decreased significantly in all groups by 1 year after the treatment. Detectable residues were found in only 8 of the 25 invertebrates sampled a year after treatment.

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Mirex Residues in the Physical Environment Following a Single Bait Application, 1971-72

James H. Spence [1] and George P. Markin [2]

ABSTRACT

In 1971 and 1972, samples of soil, sediment, water, and Bahia grass were collected at various intervals in Louisiana and Mississippi after the areas had been aerially treated with mirex to control the red imported fire ant (Solenopsis invicta *Buren). In Louisiana, samples were collected throughout the first year after spraying; in Mississippi, they were taken for the first 4 months. Samples had also been collected from the physical environment in both States before spraying began. Residues in the sediment at the bottom of ponds increased gradually after treatment, indicating that mirex was being carried in by runoff water. Residues reached maximum levels (0.7 and 1.1 ppb) about 1 month after treatment, and gradually declined thereafter. Soil residues in the Louisiana study built up to a peak of 2.5 ppb after 1 month and gradually declined over the remainder of the year. Bahia grass in Louisiana had residues in both roots and blades, indicating that some translocation occurred from the roots upward.*

In Mississippi, residue patterns of pond sediment were less predictable than in sediment of Louisiana ponds, but levels peaked at about the same interval: 1 month after treatment. Water in the pond showed the highest residue levels immediately after treatment, 0.020 and 0.530 ppb, and still had detectable levels of 0.001 to 0.005 ppb as long as 3 months after treatment. Bahia grass roots and blades were combined for analysis; the highest residue levels (26 ppb) occurred between 3 and 4 months after treatment.

Introduction

Mirex is presently the major chemical used to control the red imported fire ant (*Solenopsis invicta* Buren: formerly referred to as *Solenopsis saevissima richteri* Forel). Information about the environmental impact of mirex in bait form is very limited. Although some of the mirex that is applied as bait soon enters the biomass of an area, the degradation pattern of the remaining mirex, which is presumbaly in the physical portion of the environment, has yet to be determined.

In 1971 an in-depth study was undertaken to determine the movement and degradation pattern of mirex in an area where it had been applied to control the imported fire ant. Mirex residue levels occurring in various indicator species or groups of animals in that study have been presented in two previous papers (*1,2*). This paper reports levels of mirex residues occurring in portions of the physical environment, soil, sediment, and water at various intervals up to 1 year after treatment. Also included in this report are the residue levels found in Bahia grass (*Paspalum notatum* Flugge), the most abundant pasture grass in the area and the only plant monitored during the study.

This study was set up in Washington Parish, La. Unfortunately, it was determined that the system used for monitoring water was not satisfactory after the study had been under way for several months. Therefore, data for water from the first study site were discarded. In February 1972 a second study was set up in Harrison County, Miss., which concentrated on mirex levels in water. The newer method of sampling was not totally satisfactory but was believed to present data accurate enough for publication in this paper.

Study Area

The first study ran for 1 year in Washington Parish, La., on a 2,000-acre area of land that is farmed, grazed, or forested. The open area of the treated block was predominantly Bahia grass, hay fields, or pastures. Most of the pastures, however, contained small artificial ponds used for stock watering. Authors chose three separate

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pastures, each with its own pond, as sampling sites. Study sites were the same as those used by Markin et al. *(2)* to collect invertebrates and were in the same general area where many of the vertebrates reported by Collins et al. *(1)* had been collected.

The second study site was a 100-acre block of cutover pine forest and Bahia grass pastures located east of Saucier, Miss., in the northern part of Harrison County. The center of this plot was dominated by a 2-acre pond, the entire drainage system of which lay within the treated area. Water in the pond was sampled at both the surface and at its deepest point, approximately 1.5 m.

Both study sites were aerially treated with one application of standard 4X mirex bait (1.25 lb bait containing 1.74 g actual mirex/acre). The Louisiana block was treated May 4 and 5, 1971; the Mississippi block was treated February 15, 1972.

Sampling Procedures

Sediment samples were collected with a hand-thrown grab sampler at 10 locations around the ponds. Samples were combined at the site and a subsample was removed for analysis in the laboratory. Soil was collected from 10 random sites, each 0.1 m^2, where vegetation had been clipped and litter brushed away. Soil was removed to a depth of 7.5 cm. The 10 samples were combined on the field into a composite sample and a subsample was removed and brought to the laboratory. Grass was clipped from these areas and set aside. Dirt was shaken from the roots which were also sampled.

In the Louisiana study, stems and leaves of grass were saved as one sample; roots were a separate sample. Residues found in biological indicators that were collected have been presented elsewhere *(1,2)*. In the Mississippi study, biological indicators were not collected because the main emphasis was on determining mirex residues in water. For a more detailed description of the collection techniques used, see Markin et al. *(3)*.

In both Louisiana and Misissippi, sampling varied according to weather conditions and accessibility of the sampling sites. A sample was taken from both sites before treatment; the next sample was obtained 1-3 hours later. Subsequent collections were made 24, 48, and 72 hours after treatment; then sampling continued at various intervals for a given period of time: 4 months in Louisiana and 1 year in Mississippi.

Water was sampled with a pair of filters. The first filter, a Sears sediment filter containing a replaceable cellulose cartridge, removed suspended particulate matter. The second filter, a Sears taste/odor filter containing a replaceable activated charcoal cartridge, removed dissolved material. Water was pumped through the filters using a 115-volt submergible pump. Rate of flow varied from 25 gallons an hour at the start of a sampling period to less than 1 gallon an hour 24 hours later. Variation in flow was caused by clogging in the sediment filter which automatically reduced flow rate. To determine the total volume of water sampled during each period, three 55-gallon drums were set up in series below the filtering system to collect the filtered water so that it could be measured.

Water was collected at two locations in the pond, the pond surface and the bottom at the deepest point, 1.5 m. Surface water was taken by floating the pump in a styrofoam boat so that the pump inlet was just under the pond surface. Bottom water was sampled as water emerged from a drainage pipe under the dam. Researchers used two pumps and two separate filter systems; each had its own pump and collection barrels.

Analytical Procedures

To begin soil extraction, a 5-gallon cream can was partly filled with 5 kg moist soil, and sufficient 3:1 acetone:hexane to cover the soil to a depth of 3 cm. After 2 hours of rotation, the extract was poured through prewashed fluted filter paper into a separatory funnel. The acetone was washed out with water and the remaining hexane extract was dried over anhydrous sodium sulfate. The extract was treated with concentrated sulfuric acid until it was clear and colorless; then it was injected into the gas chromatograph. Sediment was extracted similarly except that 10-kg samples were used and the water that rose from the sediment while standing was extracted separately. Total mirex in this sample was added to mirex from the sediment sample. The Bahia grass was ground in a Waring blender with a small amount of water, extracted with acetone, then processed as the soil and sediment had been. For a detailed description of the analytical procedures above, see Markin et el. *(3)*.

The wet cellulose cartridge used to extract water was soaked with acetone, allowed to drain into a separatory funnel, soaked with methylene chloride, allowed to drain, and then soaked again with acetone. After draining was completed, the acetone was washed out with water, the bottom layer was dried over sodium sulfate, and the extract was concentrated into hexane using a Snyder column. The sample was then treated with concentrated sulfuric acid and analyzed without further concentration.

The wet charcoal from the activated charcoal filter was removed from the plastic housing and subjected to Soxhlet extraction with methylene chloride for 3 hours. After drying, the extract was concentrated into hexane and treated with concentrated sulfuric acid. The extract was then ready for analysis without further concentration. After completion of the study it was determined that extracting the activated charcoal could have been improved by multiple extractions using a wet

solvent such as water-saturated benzene to remove more mirex. This method is described by Thornburg *(4)*.

Primary indentification and quantification of mirex was accomplished on a Hewlett-Packard 402 gas chromatograph. Researchers employed two columns with different characteristics. Instrument parameters were:

Columns:	(A) Glass, 3 ft by ¼ in., packed with 3 percent DC-200 on 100/120 mesh Supelcoport.
	(B) Glass, 3 ft by ¼ in., packed with a mixture of equal portions of separately coated 3 percent DC-200 on 100/120 mesh Supelcoport and 5 percent XE-60 on 60/80 mesh Chromosorb W.
Detectors:	Electron capture, with 130 MC tritium ionizing source.
Temperatures:	Injector 235°C.
	Column 190°C.
	Detector 210°C.
Carrier Gas:	Prepurified nitrogen flowing at 90 ml/min (Column A) and 36 ml/min (Column B).
Purge Gas:	Methane: 5 percent; argon: 95 percent.

Confirmation and Recovery

Because residue levels were low, confirmation was limited to extraction p-values and retention time comparisons of spiked samples to a mirex standard. The typical responses of PCB's were not observed in any sample; presumably no PCB's were present. Recovery rates were established for the samples by spiking them with a known concentration of mirex at approximately the same level as mirex found in the samples. Recoveries were: sediment, 95 percent; soil, 97 percent; and grass, 97 percent. Tabular values for these samples have been corrected for recovery. The rate of recovery for filtered water was 70 percent, but the recovery method was not considered valid; thus tabular values for filtered water have not been corrected for recovery. Sensitivity for soil, sediment, and grass was 0.01 ppb; it was 0.001 ppb for water.

Results and Discussion

Pretreatment samples of sediment and grass showed detectable mirex residues. Although the land had never received aerial applications of bait, some landowners in both treated areas were known to have used mirex on an individual basis.

TABLE 1. *Mirex residues in sediment collected in Mississippi (1972) and Louisiana (1971-72)*

Days Posttreatment	Mirex, ppb	Cumulative Rainfall, in.
Mississippi		
Pretreatment	0.06	0.0
1-3 hours	0.16	0.0
1	0.41	0.0
2	0.17	0.0
3	0.51	0.0
7	0.11	0.3
14	0.11	0.4
21	0.30	2.4
28	0.93	4.1
35	1.1	5.3
42	0.85	6.0
49	0.04	7.1
56	0.03	7.6
63	0.20	7.6
70	0.01	7.6
77	0.02	9.5
84	0.05	11.3
91	0.10	16.1
98	0.01	19.5
105	0.76	19.5
Louisiana[1]		
Pretreatment	Neg	
1-3 hours	Neg	
3	Neg	
4	Neg	
7	0.02	
17	0.04	
25	0.30	
31	0.70	
38	0.60	
45	0.03	
54	0.08	
69	0.10	
77	0.10	
90	0.60	
117	0.30	
164	0.20	
185	0.09	
223	0.06	
268	0.50	
337	0.16	
374	0.40	

NOTE: Neg = no mirex at level of detection.
[1] Louisiana rainfall not recorded.

TABLE 2. *Mirex residues in soil collected in Mississippi (1972) and Louisiana (1971-72)*

Days Posttreatment	Mirex, ppb
Mississippi	
Pretreatment	—
1-3 hours	6.3
1	0.71
2	0.31
3	4.2
7	0.87
14	0.41
21	0.22
28	1.2
35	1.3
42	4.0
49	0.78
56	2.7
63	8.2
70	1.5
77	1.2
84	2.0
91	10.4
98	2.4
105	1.1
112	0.31
Louisiana	
Pretreatment	—
1-3 hours	0.70
3	0.70
4	0.30
7	0.80
17	0.70
25	2.0
31	2.0
38	2.5
45	2.5
54	2.5
69	1.4
77	1.4
90	1.0
117	1.0
164	0.60
185	0.90
223	0.90
268	0.20
337	0.20
374	—

NOTE: — = no data.

Mirex residues in sediment collected from the bottom of the study pond in Louisiana (1971-72) and Mississippi (1972) are shown in Table 1. Rainfall records were kept for the duration of the Mississippi studies. Mirex residues in soil collected from the two study sites are shown in Table 2. Given the rate of application, 1.7 g of actual mirex per acre, the expected residue level for mirex in the upper 7.5 cm of the soil was 3.76 ppb. In Louisiana the residue level found immediately after treatment was much below this and possibly indicates that a foraging insect such as the fire ant had collected much of the material from the soil surface. Buildup of soil residues in Louisiana over the next 54 days has been interpreted as an indication that the mirex was slowly returning to the soil through decomposition of dead insects or excretion. The decline in residues after 54 days could be caused by either degradation of mirex or translocation out of the soil. Residue levels found in soil in Mississippi are much more variable and show no distinctive pattern. A possible explanation is that bait was applied during winter months when animal activity was minimal.

Mirex residues in Bahia grass from Mississippi and Louisiana are shown in Table 3. In the Louisiana study where grass was not sampled until 69 days after treatment, the blades and roots were analyzed separately to determine mirex distribution in the Bahia grass. Mirex findings in the above-ground parts of the grass, even after thorough cleaning to remove all external dirt, indicate that some translocation was taking place from the roots to the blades. This agrees with Mehendale et al. *(5)*, who found an uptake and translocation of mirex by beans and pea seedlings in laboratory tests. In Mississippi the roots and blades were combined for analysis.

Table 4 shows mirex residues in water collected from the two sites in the Mississippi pond, using the double filter systems. Water samples from the bottom of the pond show residue values which remain higher and

TABLE 3. *Mirex residues in Bahia grass* (Paspalum notatum *Flugge) collected in Mississippi (1972) and Louisiana (1971-72)*

Days Posttreatment	Blades, ppb	Roots, ppb	Blades and roots, ppb
Mississippi			
Pretreatment	—	—	0.14
1-3 hours	—	—	6.0
1	—	—	2.7
2	—	—	4.4
3	—	—	1.8
7	—	—	4.0
14	—	—	9.0
21	—	—	1.8
28	—	—	3.2
35	—	—	1.7
42	—	—	3.7
49	—	—	14.0
56	—	—	10.0
63	—	—	4.7
70	—	—	16.0
77	—	—	12.0
84	—	—	3.9
91	—	—	16.0
98	—	—	13.0
105	—	—	26.0
112	—	—	3.1
Louisiana			
69	17.0	9.0	26.0
77	2.0	1.0	3.0
90	1.6	0.3	1.9
117	4.0	0.6	4.6
164	6.5	2.7	9.2
185	3.6	0.8	4.4
223	2.6	2.3	4.9
268	5.7	4.9	10.6
337	6.0	17.0	23.0
374	0.01	0.07	0.08

NOTE: — = no data.

TABLE 4. *Mirex residues in filtered water collected in Mississippi, 1972*

Days Posttreatment	Filter System 1 (deepest point)			Filter System 2 (pond surface)		
	Cartridge: Sediment, ppb	Cartridge: Activated Carbon, ppb	Total Mirex, ppb	Cartridge: Sediment, ppb	Cartridge: Activated Carbon, ppb	Total Mirex, ppb
Pretreatment	Neg	Neg	Neg	Neg	Neg	Neg
1-3 hours	0.033	Neg	0.033	0.007	0.009	0.016
1	0.530	Neg	0.530	0.008	0.012	0.020
2	0.001	Neg	0.001	0.003	0.004	0.007
3	0.001	0.006	0.007	0.001	0.002	0.003
7	0.001	0.007	0.008	0.005	0.001	0.006
14	0.003	0.010	0.013	0.006	0.001	0.007
21	0.002	0.012	0.014	0.002	0.003	0.005
28	Neg	0.010	0.010	0.001	0.002	0.003
35	0.001	0.012	0.012	Neg	0.002	0.002
42	Neg	0.003	0.003	Neg	0.001	0.001
49	0.004	0.004	0.008	Neg	0.002	0.002
56	0.002	0.003	0.005	Neg	Neg	Neg
63	0.001	0.009	0.010	0.001	0.001	0.002
70	0.001	0.010	0.011	0.001	0.001	0.001
77	0.001	0.005	0.006	0.001	0.001	0.001
84	0.001	0.010	0.011	0.002	Neg	0.002
91	0.002	0.003	0.005	0.002	0.001	0.003
98	0.001	0.015	0.016	0.003	Neg	0.003
105	0.001	0.003	0.004	0.007	0.003	0.010
112	0.001	0.002	0.003	0.005	0.002	0.007

NOTE: Neg = no mirex at level of detection.

more constant than those from the surface of the pond. Because sample water flowed through both the sediment and the activated charcoal filters, the total mirex residue load for each sampling period is determined by adding the figures for the two different filters. In general, highest residue levels were found immediately after treatment.

Acknowledgment

For assistance and suggestions, authors are indebted to Dudley J. Adams, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Gulfport, Miss.

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BRIEFS

Organochlorine Insecticide Residues in Carpeting [1]

David L. Mick,[2] Herbert Hetzler,[1] and Edwin Slach [1]

ABSTRACT

Organochlorine insecticide (OCI) residues were detected by gas-liquid chromatography in carpet samples in 1973. Dieldrin was found in largest quantities; it was also found most frequently, existing in 84 percent of the samples. Wool carpet had higher residue levels than did synthetic carpet. OCI residues were also found in raw wool, but at much lower levels, indicating that most of the residues had been absorbed at the carpet mill rather than on the farm.

Introduction

Insect damage to carpeting can be prevented at carpet mills by treating fibers with insecticides during the manufacturing process. Garrison and Hill found dieldrin residues while monitoring the aqueous effluent of a mill *(1)*. Their research stimulated this study to determine organochlorine insecticide residue levels in carpeting. The authors wished to explore carpeting as a possible source of insecticide residues in organic samples, particularly human tissue, which have no apparent exposure to chlorinated hydrocarbons.

Sampling and Analytical Procedures

Carpet remnants were obtained from carpet retailers and homes around Iowa City, Iowa, in 1973. Selection was not based upon any specific manufacturer, fiber, or color. No chlorinated hydrocarbon insecticides had been applied in the vicinity of the carpets while in the store or home.

Researchers extracted 10-g samples of one-inch carpet squares by immersing them in 500-ml, glass-stoppered, Erlenmeyer flasks with 200 ml n-hexane for 15 minutes, hand-shaking the flasks for 5 minutes, and filtering the solutions through Whatman No. 1 filter paper. The n-hexane extract was concentrated by flash evaporation to approximately 5 ml prior to cleanup on a florisil column. The column was first eluted with 200 ml 6 percent diethyl ether in petroleum ether and then with 200 ml 15 percent diethyl ether in petroleum ether.

Eluates were concentrated to approximately 5 ml and subsequently analyzed by gas-liquid chromatography using QF-1/SF-30 and DEGS columns. Sensitivity was approximately 0.001 ppm for aldrin, dieldrin, lindane, and *p,p'*-DDE, and 0.002 ppm for *p,p'*-DDT. Thin-layer chromatography was used to confirm detected residues.

Results and Discussion

Every carpet sampled revealed residues of at least one chlorinated hydrocarbon: aldrin, DDE, DDT, dieldrin, or lindane (Table 1). DDT and dieldrin were found most frequently, occurring in 15 and 21 of the 25 samples, respectively; Dieldrin was found in considerably higher quantities than any other insecticide. Highest residue levels of DDT and dieldrin appeared in wool carpeting. These levels probably result from treatment at the mill rather than on the farm, although the current study produces only limited evidence to support this conclusion.

To establish a control for wool samples, raw wool was obtained from a central Iowa farm and processed as the carpet samples had been. Although wool was sampled from only one farm (25-30 sheep), authors consider it representative of raw wool throughout the West and Midwest which is used in the manufacture of carpeting. Chlorinated hydrocarbon insecticides detected in a 6.7-g sample of raw wool are shown in Table 2. The fact that the raw wool contained residues indicated that the environment of sheep contributes to insecticide residue levels found in wool carpet samples. But these

[1] Iowa Community Pesticides Study, Institute of Agricultural Medicine, College of Medicine, University of Iowa. (Reprints are available from this address.) Work was performed pursuant to U.S. Environmental Protection Agency—Office of Pesticides Programs, Technical Services Division Contract No. 68-02-0746.

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TABLE 1. *Chlorinated hydrocarbon insecticide residues in carpeting, Iowa City, Iowa—1973*

Fiber	Residue Levels, ppm				
	Aldrin	Dieldrin	*p,p'*-DDT	*p,p'*-DDE	Lindane
Wool	0	27,638	0.638	0.036	0
"	0	9,684	0.424	0.159	0
"	0.105	9,331	0.234	0	0
"	0.022	7,391	0.030	0	0
Synthetic	0	25,393	0.142	0	0
"	0.070	2,383	0	0	0
"	0	0.956	0.240	0.032	0
"	0.011	0.825	0	0	0
"	0	0.497	0.028	0	0
"	0	0.361	0	0	0
"	0	0.119	0.082	0	0
"	0	0.116	0.095	0	0
"	0	0.075	0	0	0
"	0.026	0.071	0	0	0
"	0	0.040	0.021	0	0
"	0	0.026	0.051	0	0
"	0	0.019	0	0	0
"	0	0.010	0	0	0
"	0.010	0.008	0	0	0.007
"	0	0.007	0	0	0
"	0	0.004	0	0	0
"	0.041	0	0.063	0	0.015
"	0.049	0	0.086	0	0
"	0	0	0.025	0	0
"	0	0	0.863	0	0

TABLE 2. *Chlorinated hydrocarbon insecticide residues in raw wool, Iowa—1973*

Insecticide	Residue Levels, ppm
p,p'-DDT	0.064
p,p'-DDE	0.009
o,p'-DDT	0.015
Dieldrin	0.017

levels were not great enough to account for all residues detected in the samples.

Recovery studies indicate that the extraction process detected 85 to 100 percent of the residues in both wool and synthetic carpet. This is based upon the difference in insecticide residues recovered from nonspiked samples contrasted to those recovered from spiked samples. As postulated earlier, results of this study provide evidence for a potential source of human exposure to chlorinated hydrocarbon insecticides. Findings may help explain why insecticide residue levels are sometimes detected in organic samples, such as human tissue, with no apparent source of exposure.

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Organochlorine Pesticide Residue Levels in North American Timber Wolves—1969-71

James C. Schneeweis,[1] Yvonne A. Greichus,[2] and Raymond L. Linder [3]

ABSTRACT

Tongue and muscle tissue samples from 51 timber wolves captured in Minnesota and northwest Ontario in 1969-71 were analyzed for organochlorine pesticide residues in an attempt to determine the level of insecticide contamination in their environment. No determined residue levels exceeded the minimum analytical confidence limits established in a previous study by one of the authors. The implementation of new State, national, and international legislation protecting timber wolves makes this study especially valuable because samples from a wide range of age groups will no longer be readily available for analysis.

Introduction

The timber wolf (*Canis lupus*) has recently become a symbol of wilderness environments. Because these mammals are at the top of their food chain, one would expect their tissues to contain pesticide residues if their environment were contaminated by organochlorine compounds. The purpose of this paper is to report results of analyses of timber wolf tissues for selected pesticides. This study is especially valuable because recent State, national, and international legislation protecting timber wolves has made samples from a wide variety of age groups more difficult to obtain for analysis.

Analytical Methods

Tongue and muscle tissue samples were taken from 51 timber wolves captured by hunters and trappers: 30 from the winter of 1969-70 and 21 from 1970-71. No animals were collected specifically for this study. Wolves were assigned an age class based on examination of the gross size and weight of the carcass, wear and development of the teeth, and, in some cases, development of the cranium (Table 1). Wolves were from Koochiching and northwest St. Louis Counties, Minn., and from northwest Ontario, Canada. The area is wild to semiwild in nature and is primarily coniferous forest with little or no human disturbance.

Samples were kept frozen until they were analyzed in the Experiment Station Biochemistry Laboratory, South Dakota State University. Analytical procedures were those reported by Greichus, et al. (*1,2*).

Results

No determined residue levels exceeded the minimum analytical confidence limits establishd by Greichus in 1973 (*2*). These limits are: lindane, heptachlor, heptachlor epoxide, aldrin, dieldrin, and DDE—0.01 parts per million (ppm); DDT and DDD—0.05 ppm; and PCB's, endrin, and methoxychlor—1.00 ppm. These data suggest that pesticide contamination was quite low in specified areas of Minnesota and Ontario.

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[1] Minnesota Department of Natural Resources, International Falls, Minn. 56649.
[2] Experiment Station Biochemistry Department, South Dakota State University, Brookings, S. Dak.
[3] South Dakota Cooperative Wildlife Research Unit, Brookings, S. Dak.

TABLE 1. *Sex and age class[1] of 51 North American timber wolves analyzed for insecticide residues, 1969-71*

Year[2]	Number Analyzed						
	Males			Females			
	Adults	Juveniles	Age Unknown	Adults	Juveniles	Age Unknown	Total
1969-70	12	0	2	5	5	6	30
1970-71	ND	ND	8	ND	ND	13	21
Total	12	0	10	5	5	19	51

NOTE: ND = no data.
[1] Juveniles were those born around the preceding spring.
[2] Samples were obtained both winters between December and March.

APPENDIX

Chemical Names of Compounds Discussed in This Issue[1]

ALDRIN	Not less than 95% of 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
AMIBEN	3-Amino-2,5-dichlorobenzoic acid
AMITROLE	3-Amino-1,2,4-triazole
ATRAZINE	2-Chloro-4-ethylamino-6-isopropylamino-*s*-triazine
BHC (BENZENE HEXACHLORIDE)	1,2,3,4,5,6-Hexachlorocyclohexane (mixture of isomers). Commercial product contains several isomers of which *gamma* is most active as an insecticide.
BIDRIN ●	See dicrotophos.
BOTRAN ●	See dichloran.
CAPTAN	*N*-Trichloromethylthio-4-cyclohexane-1,2-dicarboximide
CARBARYL	1-Naphthyl *N*-methylcarbamate
CHLORDANE	1,2,3,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindane. The technical product is a mixture of several compounds including heptachlor, chlordene, and two isomeric forms of chlordane.
CHLORPROPHAM	Isopropyl *N*-(3-chlorophenyl) carbamate
CIPC	See chlorpropham.
COTORAN ●	See fluometuron.
2,4-D	2,4-Dichlorophenoxyacetic acid
DACTHAL ●	See DCPA.
DCPA	Dimethyl 2,3,5,6-tetrachloroterephthalate
DDD	See TDE.
DDE	Dichlorodiphenyl dichloro-ethylene (degradation product of DDT). Main component (*p,p'*-DDE): 1,1-Dichloro-2,2-bis(*p*-chlorophenyl) ethylene *o,p'*-DDE: 1,1-Dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethylene
DDT	Main component (*p,p'*-DDT): α-Bis(*p*-chlorophenyl)β,β,β-trichloroethane Other isomers are possible and some are present in the commercial product. *o,p'*-DDT: [1,1,1-Trichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethane]
DEF ●	*S,S,S*-Tributyl phosphorotrithioate
DIAZINON	*0,0*-Diethyl *0*-(2-isopropyl 4-methyl-6-pyrimidyl) phosphorothioate
DICHLORAN	2,6-Dichloro-4-nitroaniline
DICOFOL	4,4'-Dichloro-α-trichloromethylbenzhydrol
DICROTOPHOS	3-(Dimethoxyphosphinyloxy)-*N,N*-dimethyl-*cis*-crotonamide
DIELDRIN	Not less than 85% of 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
DIURON	3-(3,4-Dichlorophenyl)-1,1-dimethyl-urea
ENDOSULFAN	6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
ENDRIN	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-endo*-5,8-dimethanonaphthalene
FLUOMETURON	3-(*m*-Trifluoromethylphenyl)-1,1-dimethylurea
FOLEX	Tributyl phosphorotrithioite
HCB	Hexachlorobenzene
HEPTACHLOR	1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-*endo*-methanoindene
HEPTACHLOR EPOXIDE	1,4,5,6,7,8,8-Heptachloro 2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindane
KELTHANE ●	See dicofol.
LINDANE	Gamma isomer of Benzene Hexachloride (1,2,3,4,5,6-hexachlorocyclohexane) of 99+% purity
MALATHION	*S*-[1,2-Bis(ethoxycarbonyl)ethyl] *0,0*-dimethyl phosphorodithioate
METHOXYCHLOR	1,1,1-Trichloro-2,2-bis(*p*-methoxyphenyl) ethane
METHYL PARATHION	*0,0*-Dimethyl *0*-*p*-nitrophenyl phosphorothioate
MIREX	Dodecachlorooctahydro-1,3,4-metheno-1H-cyclobuta[cd]pentalene
MSMA	Methanearsonic acid, monosodium salt
PARATHION	*0,0*-Diethyl-*0*-*p*-nitrophenyl phosphorothioate
PCB's (POLYCHLORINATED BIPHENYLS)	Mixtures of chlorinated biphenyl compounds having various percentages of chlorine.
PCP	Pentachlorophenol
PERTHANE	1,1-Dichloro-2,2-bis(*p*-ethylphenyl) ethane
o-PHENYLPHENOL	orthophenylphenol
PHOSALONE	*0,0*-Diethyl *S*-(6-chloro-2-oxo-benzoxazolin-3-yl) methyl phosphorodithioate
PROPACHLOR	2-Chloro-*N*-isopropylacetaniliide
RAMROD ●	See propachlor.
RONNEL	Dimethyl 2,4,5-trichlorophenyl phosphorothionate
TDE	2,2-Bis (*p*-chlorophenyl)-1,1-dichloroethane (including isomers and dehydrochlorination products)
TOXAPHENE	Chlorinated camphene (67-69% chlorine); product is a mixture of polychlor bicyclic terpens with chlorinated camphenes predominating.
TRIFLURALIN	α,α,α-Trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine

[1] Does not include chemicals listed only in tables of papers by Crockett et al. and Manske/Corneliussen.

ERRATUM

PESTICIDES MONITORING JOURNAL, Volume 7, Number 1. In the paper "Mercury, Lead, Cadmium, and Arsenic Residues in Starlings—1971," page 69, Table 1, first two columns: analysis was performed in the city of Laurel, Maryland, rather than in Patuxent, Maryland.

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